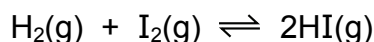


1. Question | 9701 Feb-March 2016 P1 V2 Q11

- 11** In an experiment, 2.00 mol of hydrogen and 3.00 mol of iodine were heated together in a sealed container and allowed to reach equilibrium at a fixed temperature. The container had a fixed volume of 1.00 dm³. At equilibrium, there were 2.40 mol of iodine present in the mixture.



What is the value of the equilibrium constant, K_c ?

- A** 0.107 **B** 0.357 **C** 0.429 **D** 2.33

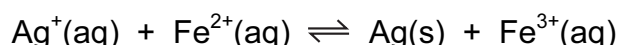
2. Question | 9701 Feb-March 2016 P1 V2 Q33

- 33** Which statements about reversible reactions are correct?

- 1** An increase in concentration of a reactant always increases the concentration of the product.
- 2** An increase in temperature always increases the rate at which the equilibrium is established.
- 3** An increase in temperature always increases the concentration of the product at equilibrium.

3. Question | 9701 May-June 2016 P1 V1 Q9

- 9** An aqueous solution was prepared containing a mixture of 1.0 mol of AgNO₃ and 1.0 mol of FeSO₄ in 1.00 dm³ of water. When equilibrium was established, there was 0.44 mol of Ag⁺(aq) in the mixture.

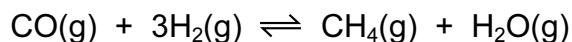


What is the numerical value of K_c ?

- A** 0.62 **B** 1.40 **C** 1.62 **D** 2.89

4. Question | 9701 May-June 2016 P1 V1 Q10

- 10** The equation for the reaction between carbon monoxide and hydrogen is shown.



What are the units of K_p for this reaction?

- A** kPa **B** kPa⁻¹ **C** kPa² **D** kPa⁻²

5. Question | 9701 May-June 2016 P1 V2 Q10

- 10** When solid ammonium chloride dissociates at a certain temperature in a 0.500 dm³ container, ammonia and hydrogen chloride are formed.



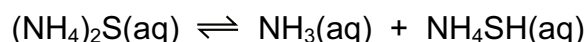
The initial amount of ammonium chloride was 1.00 mol, and when the system had reached equilibrium there was 0.300 mol of ammonium chloride.

What is the numerical value of K_c for this reaction under these conditions?

- A** 0.490 **B** 1.63 **C** 1.96 **D** 3.27

6. Question | 9701 May-June 2016 P1 V2 Q15

- 15** Ammonia gas, NH₃, and hydrogen sulfide gas, H₂S, react together to form the salt ammonium sulfide, (NH₄)₂S. Ammonium sulfide dissolves in water to produce an orange alkaline solution.



The addition of NaOH(aq) to this solution produces a gas, **X**.

The addition of HCl(aq) to a separate portion of this solution produces a gas, **Y**.

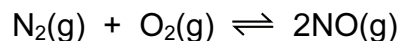
What are the identities of **X** and **Y**?

	X	Y
A	H ₂ S	H ₂ S
B	H ₂ S	NH ₃
C	NH ₃	H ₂ S
D	NH ₃	NH ₃

7. Question | 9701 May-June 2016 P1 V2 Q33

33 In this question, all gases can be assumed to behave ideally.

A chemist heats a mixture of nitrogen and oxygen gases in a sealed container at a constant temperature until the mixture reaches a dynamic equilibrium containing $\text{N}_2(\text{g})$, $\text{O}_2(\text{g})$ and $\text{NO}(\text{g})$.



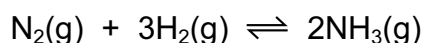
The chemist repeats the experiment at the same temperature using the same initial amounts of $\text{N}_2(\text{g})$ and $\text{O}_2(\text{g})$, but at a much higher pressure.

Which statements about the second experiment at higher pressure are correct?

- 1 At higher pressure, there are more particles per unit volume.
- 2 The composition of the equilibrium mixture does not change.
- 3 There are more collisions per second so equilibrium is reached faster.

8. Question | 9701 May-June 2016 P1 V3 Q9

9 The equilibrium constant, K_c , for the reaction shown is $2 \text{ mol}^{-2} \text{ dm}^6$, at 600 K.



What is the concentration of NH_3 at equilibrium, at 600 K, when the equilibrium concentrations of N_2 and H_2 are both 2 mol dm^{-3} ?

- A** $\sqrt{8} \text{ mol dm}^{-3}$ **B** $\sqrt{16} \text{ mol dm}^{-3}$ **C** $\sqrt{32} \text{ mol dm}^{-3}$ **D** 32 mol dm^{-3}

9. Question | 9701 May-June 2016 P1 V3 Q11

11 Catalysts are an important feature of many industrial processes and biochemical reactions.

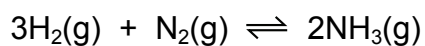
Which row correctly describes the effect of a catalyst on a reversible chemical reaction?

	position of equilibrium	effect on value of ΔH
A	moved to right	decreased
B	unaffected	decreased
C	unaffected	increased
D	unaffected	unaffected

10. Question | 9701 Oct-Nov 2016 P1 V1 Q10

10 The table shows the partial pressures in an equilibrium mixture formed by the Haber process.

substance	partial pressure / kPa
nitrogen	7000
hydrogen	8000
ammonia	4000

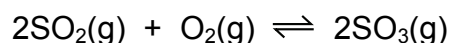


What is the numerical value of the equilibrium constant, K_p , for this reaction?

- A** 4.46×10^{-9}
- B** 4.76×10^{-5}
- C** 7.14×10^{-5}
- D** 2.24×10^8

11. Question | 9701 Oct-Nov 2016 P1 V1 Q34

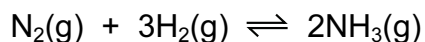
34 In the manufacture of sulfuric acid, the following exothermic reaction occurs.



Which changes will move the position of the equilibrium to the right?

- 1** increasing the pressure
- 2** increasing the temperature
- 3** using twice as much catalyst

10 Nitrogen reacts with hydrogen to produce ammonia.



A mixture of 2.00 mol of nitrogen, 6.00 mol of hydrogen and 2.40 mol of ammonia is allowed to reach equilibrium in a sealed vessel of volume 1 dm³. It was found that 2.32 mol of nitrogen were present in the equilibrium mixture.

What is the value of K_c ?

A $\frac{(1.76)^2}{(2.32)(6.96)^3}$

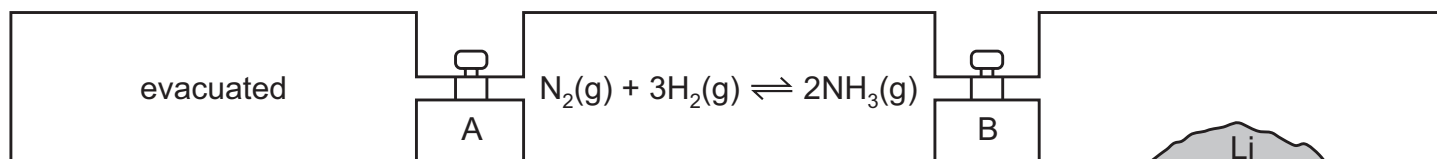
B $\frac{(1.76)^2}{(2.32)(6.32)^3}$

C $\frac{(2.08)^2}{(2.32)(6.32)^3}$

D $\frac{(2.40)^2}{(2.32)(6.00)^3}$

11 Lithium reacts with nitrogen at room temperature to form solid Li_3N .

Three vessels of equal volume are connected by taps, A and B, as shown.



At the start, A and B are closed, the left-hand vessel is evacuated, the middle vessel has the indicated reaction at equilibrium and the right-hand vessel contains lithium only.

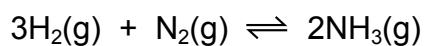
Which action would allow the equilibrium mixture to contain the **most** ammonia?

- A** Keep both A and B closed.
- B** Open both A and B.
- C** Open A only.
- D** Open B only.

14. Question | 9701 Oct-Nov 2016 P1 V3 Q10

10 The table shows the partial pressures in an equilibrium mixture formed by the Haber process.

substance	partial pressure / kPa
nitrogen	7000
hydrogen	8000
ammonia	4000

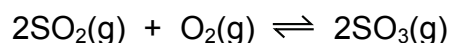


What is the numerical value of the equilibrium constant, K_p , for this reaction?

- A** 4.46×10^{-9}
- B** 4.76×10^{-5}
- C** 7.14×10^{-5}
- D** 2.24×10^8

15. Question | 9701 Oct-Nov 2016 P1 V3 Q34

34 In the manufacture of sulfuric acid, the following exothermic reaction occurs.



Which changes will move the position of the equilibrium to the right?

- 1** increasing the pressure
- 2** increasing the temperature
- 3** using twice as much catalyst

16. Question | 9701 Feb-March 2017 P1 V2 Q3

- 3** Two moles of compound P were placed in a sealed container. The container was heated and P was partially decomposed to produce Q and R only. A dynamic equilibrium between P, Q and R was established.

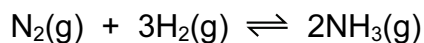
At equilibrium x moles of R were present and the total number of moles present was $\left(2 + \frac{x}{2}\right)$.

What is the equation for this reversible reaction?

- A** $P \rightleftharpoons 2Q + R$
- B** $2P \rightleftharpoons 2Q + R$
- C** $2P \rightleftharpoons Q + R$
- D** $2P \rightleftharpoons Q + 2R$

17. Question | 9701 Feb-March 2017 P1 V2 Q11

11 Ammonia is manufactured from nitrogen and hydrogen using the Haber process.



What is the expression for K_c for this equilibrium?

A $\frac{2[\text{NH}_3(\text{g})]}{[\text{N}_2(\text{g})] + 3[\text{H}_2(\text{g})]}$

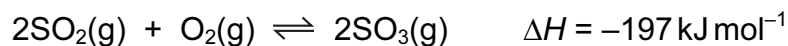
B $\frac{2[\text{NH}_3(\text{g})]}{[\text{N}_2(\text{g})] \times 3[\text{H}_2(\text{g})]}$

C $\frac{[\text{NH}_3(\text{g})]^2}{[\text{N}_2(\text{g})] + [\text{H}_2(\text{g})]^3}$

D $\frac{[\text{NH}_3(\text{g})]^2}{[\text{N}_2(\text{g})] \times [\text{H}_2(\text{g})]^3}$

18. Question | 9701 Feb-March 2017 P1 V2 Q34

34 Sulfur dioxide and oxygen react in the gas phase.

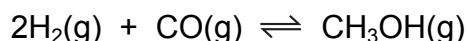


Which statements are correct?

- 1** Increasing the pressure increases the equilibrium yield of SO_3 .
- 2** Increasing the temperature lowers the value of the equilibrium constant K_p .
- 3** The presence of a vanadium(V) oxide catalyst increases the equilibrium yield of SO_3 .

19. Question | 9701 May-June 2017 P1 V1 Q10

10 Methanol can be produced from hydrogen and carbon monoxide.



What is the expression for K_p for this reaction?

A $K_p = \frac{(2p_{\text{H}_2})^2 \times p_{\text{CO}}}{p_{\text{CH}_3\text{OH}}}$

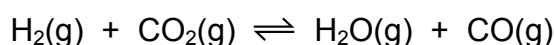
B $K_p = \frac{(p_{\text{H}_2})^2 \times p_{\text{CO}}}{p_{\text{CH}_3\text{OH}}}$

C $K_p = \frac{p_{\text{CH}_3\text{OH}}}{(p_{\text{H}_2})^2 \times p_{\text{CO}}}$

D $K_p = \frac{p_{\text{CH}_3\text{OH}}}{p_{\text{CO}} \times (2p_{\text{H}_2})^2}$

20. Question | 9701 May-June 2017 P1 V2 Q9

9 Hydrogen and carbon dioxide gases are mixed at 800 K. A reversible reaction takes place.



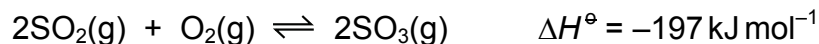
At equilibrium, the partial pressures of H_2 and CO_2 are both 10.0 kPa. K_p is 0.288 at 800 K.

What is the partial pressure of CO in the equilibrium mixture?

- A** 5.37 kPa **B** 18.6 kPa **C** 28.8 kPa **D** 347 kPa

21. Question | 9701 May-June 2017 P1 V2 Q10

10 A reaction involved in the Contact process is shown.



The reaction is investigated at 200 kPa and 700 K and the value of the equilibrium constant, K_p , is found to be Y. The reaction is then investigated at 1000 kPa and 700 K and the value of K_p is found to be Z.

Which statement comparing Y and Z is correct?

- A** Y and Z are the same.
- B** Y is greater than Z.
- C** Z is 2.2 times greater than Y.
- D** Z is 5.0 times greater than Y.

22. Question | 9701 May-June 2017 P1 V3 Q9

9 Ammonia is produced by the Haber process.



A fault in the temperature control during the process resulted in the temperature changing to 600 °C for two hours.

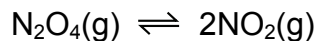
What effect did this have on the ammonia production during this time?

- A** Ammonia was formed faster. The equilibrium yield decreased.
- B** Ammonia was formed faster. The equilibrium yield increased.
- C** Ammonia was formed slower. The equilibrium yield decreased.
- D** Ammonia was formed slower. The equilibrium yield increased.

23. Question | 9701 May-June 2017 P1 V3 Q10

10 For the reaction shown, an equilibrium is established at a temperature of 700 K.

The equilibrium constant, K_p , for the reaction is 9.80 kPa. The partial pressure of N_2O_4 at equilibrium is 80.0 kPa.

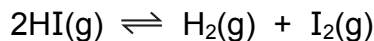


What is the partial pressure of NO_2 at equilibrium?

- A** 8.16 kPa **B** 28.0 kPa **C** 66.6 kPa **D** 784 kPa

24. Question | 9701 Oct-Nov 2017 P1 V1 Q9

9 Hydrogen iodide dissociates into hydrogen and iodine.



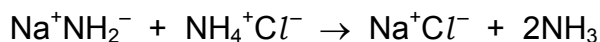
In an experiment, b mol of hydrogen iodide were put into a sealed vessel at pressure p . At equilibrium, x mol of the hydrogen iodide had dissociated.

Which expression for K_p is correct?

- A** $\frac{x^2}{(b-x)^2}$ **B** $\frac{x^2 p^2}{(b-x)^2}$ **C** $\frac{x^2 p^2}{4b(b-x)}$ **D** $\frac{x^2}{4(b-x)^2}$

25. Question | 9701 Oct-Nov 2017 P1 V1 Q34

34 The following reaction takes place in a suitable solvent.



Which statements explain why this reaction should be classified as a Brønsted-Lowry acid-base reaction?

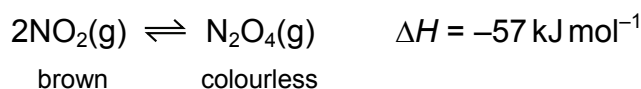
- 1** The ammonium ion acts as a proton donor.
- 2** Na^+Cl^- is a salt.
- 3** Ammonia is a nucleophile.

26. Question | 9701 Oct-Nov 2017 P1 V2 Q9

9 Nitrogen dioxide, NO_2 , is a brown gas.

Dinitrogen tetroxide, N_2O_4 , is a colourless gas.

An equilibrium is established between NO_2 and N_2O_4 in a closed vessel.



Which row describes the effects of changing conditions on the colour of an equilibrium mixture of NO_2 and N_2O_4 ?

	increasing the pressure	increasing the temperature
A	colour becomes darker	colour becomes darker
B	colour becomes darker	colour becomes lighter
C	colour becomes lighter	colour becomes darker
D	colour becomes lighter	colour becomes lighter

27. Question | 9701 Oct-Nov 2017 P1 V2 Q34

34 Methanoic acid, HCO_2H , and hydrocyanic acid, HCN , can both behave as acids.

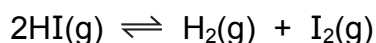
A solution of methanoic acid has a lower pH than a solution of hydrocyanic acid of the same concentration.

Which statements explain this?

- 1 HCO_2H molecules dissociate more fully than HCN molecules do.
- 2 Each HCO_2H molecule has two hydrogen atoms; each HCN molecule only has one.
- 3 Methanoic acid is a weaker acid than hydrocyanic acid.

28. Question | 9701 Oct-Nov 2017 P1 V3 Q9

9 Hydrogen iodide dissociates into hydrogen and iodine.



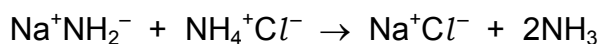
In an experiment, b mol of hydrogen iodide were put into a sealed vessel at pressure p . At equilibrium, x mol of the hydrogen iodide had dissociated.

Which expression for K_p is correct?

- A** $\frac{x^2}{(b-x)^2}$ **B** $\frac{x^2 p^2}{(b-x)^2}$ **C** $\frac{x^2 p^2}{4b(b-x)}$ **D** $\frac{x^2}{4(b-x)^2}$

29. Question | 9701 Oct-Nov 2017 P1 V3 Q34

34 The following reaction takes place in a suitable solvent.



Which statements explain why this reaction should be classified as a Brønsted-Lowry acid-base reaction?

- 1 The ammonium ion acts as a proton donor.
- 2 Na^+Cl^- is a salt.
- 3 Ammonia is a nucleophile.

30. Question | 9701 Feb-March 2018 P1 V2 Q11

11 The reaction between sulfur dioxide and oxygen is reversible.



Which conditions of pressure and temperature favour the **reverse** reaction?

	pressure	temperature
A	high	high
B	high	low
C	low	high
D	low	low

31. Question | 9701 Feb-March 2018 P1 V2 Q12

12 Which statement about the effect of a catalyst on a reversible reaction is correct?

- A** The activation energy of the forward reaction stays the same.
- B** The composition of the equilibrium mixture stays the same.
- C** The rate of the backward reaction stays the same.
- D** The value of the equilibrium constant changes.

32. Question | 9701 Feb-March 2018 P1 V2 Q34

34 In which reactions does NH_3 behave as a Brønsted-Lowry acid?

- 1** $2\text{NH}_3 \rightarrow \text{NH}_2^- + \text{NH}_4^+$
- 2** $\text{HSO}_4^- + \text{NH}_3 \rightarrow \text{SO}_4^{2-} + \text{NH}_4^+$
- 3** $\text{Ag}^+ + 2\text{NH}_3 \rightarrow [\text{Ag}(\text{NH}_3)_2]^+$

33. Question | 9701 May-June 2018 P1 V1 Q15

15 In which reaction does ammonia behave as a Brønsted-Lowry base?

- A** $\text{NH}_3 + \text{CH}_3\text{CH}_2\text{Br} \rightarrow \text{CH}_3\text{CH}_2\text{NH}_2 + \text{HBr}$
- B** $\text{NH}_3 + \text{H}_2\text{O} + \text{CO}_2 \rightarrow (\text{NH}_4)\text{HCO}_3$
- C** $2\text{NH}_3 + 2\text{Na} \rightarrow 2\text{NaNH}_2 + \text{H}_2$
- D** $4\text{NH}_3 + 3\text{O}_2 \rightarrow 2\text{N}_2 + 6\text{H}_2\text{O}$

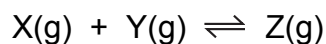
34. Question | 9701 May-June 2018 P1 V1 Q34

34 Which statements are correct when a reversible reaction is at equilibrium?

- 1** All species are at equal concentration.
- 2** The concentrations of all species remain constant.
- 3** The rate of the forward reaction equals the rate of the reverse reaction.

35. Question | 9701 May-June 2018 P1 V2 Q5

5 The gases X and Y react to form Z.



An equilibrium mixture of these three gases is compressed at constant temperature.

What will be the changes in the mole fraction of Z and in K_p ?

	mole fraction of Z	K_p
A	increase	increase
B	increase	no change
C	no change	increase
D	no change	no change

36. Question | 9701 May-June 2018 P1 V2 Q10

10 In a particular reversible reaction the yield of product is increased

- if the temperature is increased;
- if the pressure is decreased.

Which equation could describe this reversible reaction?

- A** $\text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g}) \rightleftharpoons 3\text{H}_2(\text{g}) + \text{CO}(\text{g})$ $\Delta H = +206 \text{ kJ mol}^{-1}$
- B** $4\text{NH}_3(\text{g}) + 3\text{O}_2(\text{g}) \rightleftharpoons 2\text{N}_2(\text{g}) + 6\text{H}_2\text{O}(\text{g})$ $\Delta H = -227 \text{ kJ mol}^{-1}$
- C** $2\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$ $\Delta H = -58 \text{ kJ mol}^{-1}$
- D** $3\text{O}_2(\text{g}) \rightleftharpoons 2\text{O}_3(\text{g})$ $\Delta H = +143 \text{ kJ mol}^{-1}$

37. Question | 9701 May-June 2018 P1 V2 Q34

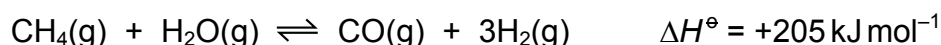
34 The temperature of a reversible gas phase reaction is increased.

Which statements are **always** correct?

- 1** More product is present at equilibrium.
- 2** The average speed of the particles increases.
- 3** There are more successful collisions per unit time.

38. Question | 9701 May-June 2018 P1 V3 Q9

9 Hydrogen is produced industrially from methane as shown in the equation.

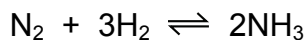


Which conditions would most favour the formation of hydrogen?

	pressure	temperature
A	high	high
B	high	low
C	low	high
D	low	low

39. Question | 9701 May-June 2018 P1 V3 Q10

10 The chemical equilibrium shown is formed when ammonia is produced in the Haber process.



The following concentrations are found to be present at equilibrium under certain conditions.

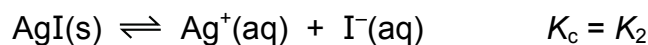
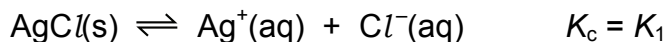
N_2	H_2	NH_3
$0.200 \text{ mol dm}^{-3}$	$0.300 \text{ mol dm}^{-3}$	$0.600 \text{ mol dm}^{-3}$

What is the numerical value of K_c under these conditions?

- A** 0.0150 **B** 6.0 **C** 10.0 **D** 66.7

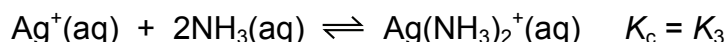
40. Question | 9701 May-June 2018 P1 V3 Q17

17 Silver chloride and silver iodide form equilibria when added to water.



Each equilibrium position lies well to the **left**.

Silver iodide will not dissolve in aqueous ammonia. Silver chloride will dissolve in aqueous ammonia. Another equilibrium is formed.



The position of this equilibrium lies to the **right**.

What is the order of magnitude for these three equilibrium constants?

A $K_1 > K_2 > K_3$

B $K_2 > K_1 > K_3$

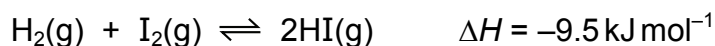
C $K_3 > K_1 > K_2$

D $K_3 > K_2 > K_1$

41. Question | 9701 Oct-Nov 2018 P1 V1 Q9

9 In this question you should assume that all gases behave ideally.

Hydrogen and iodine react reversibly in the following reaction. The system reaches dynamic equilibrium.



Which statement **must** be true for the K_p of this equilibrium to be constant?

A The partial pressures of H_2 , I_2 and HI are equal.

B The external pressure is constant.

C The forward and reverse reactions have stopped.

D The temperature is constant.

42. Question | 9701 Oct-Nov 2018 P1 V1 Q10

- 10** 0.200 mol of sulfur dioxide and 0.200 mol of oxygen are placed in a 1.00 dm^3 sealed container. The gases are allowed to react until equilibrium is reached.



At equilibrium there is 0.100 mol of SO_3 in the container.

What is the value of K_c ?

- A** $0.150 \text{ mol dm}^{-3}$
B $0.800 \text{ mol dm}^{-3}$
C $1.25 \text{ mol}^{-1} \text{ dm}^3$
D $6.67 \text{ mol}^{-1} \text{ dm}^3$

43. Question | 9701 Oct-Nov 2018 P1 V2 Q9

- 9** In this question, all pressures are measured in atm.

The equation represents the equilibrium between three gaseous substances X, Y and Z.



At temperature T_1 , the numerical value of K_p , the equilibrium constant, is 2.

At a higher temperature T_2 , the partial pressures at equilibrium are as shown.

X	Y	Z
2	3	5

Which row is correct?

	the numerical value of K_p at T_2	the forward reaction is
A	54 / 25	endothermic
B	54 / 25	exothermic
C	25 / 54	endothermic
D	25 / 54	exothermic

44. Question | 9701 Oct-Nov 2018 P1 V2 Q11

11 Nitrogen and hydrogen can react together to form ammonia.

The formation of ammonia is exothermic.

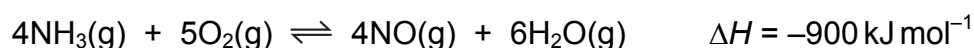
The rate and yield of the reaction can be altered by changing the conditions under which the reaction is carried out.

Which row shows the effects of adding iron to the mixture **and** increasing the temperature?

	adding iron	increasing the temperature
A	has no effect on the equilibrium yield	reduces the equilibrium yield
B	increases the equilibrium yield	increases the equilibrium yield
C	increases the equilibrium yield	increases the rate
D	increases the rate	has no effect on the equilibrium yield

45. Question | 9701 Oct-Nov 2018 P1 V2 Q34

34 The equation represents an equilibrium.



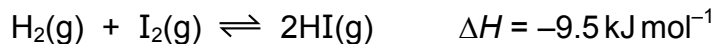
What would increase the concentration of NO at equilibrium?

- 1 a reduction in the reaction temperature
- 2 the use of a suitable catalyst
- 3 an increase in the total pressure

46. Question | 9701 Oct-Nov 2018 P1 V3 Q9

9 In this question you should assume that all gases behave ideally.

Hydrogen and iodine react reversibly in the following reaction. The system reaches dynamic equilibrium.

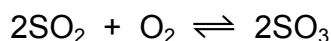


Which statement **must** be true for the K_p of this equilibrium to be constant?

- A The partial pressures of H_2 , I_2 and HI are equal.
- B The external pressure is constant.
- C The forward and reverse reactions have stopped.
- D The temperature is constant.

47. Question | 9701 Oct-Nov 2018 P1 V3 Q10

10 0.200 mol of sulfur dioxide and 0.200 mol of oxygen are placed in a 1.00 dm^3 sealed container. The gases are allowed to react until equilibrium is reached.

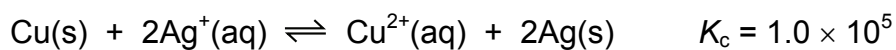


At equilibrium there is 0.100 mol of SO_3 in the container.

What is the value of K_c ?

- A $0.150 \text{ mol dm}^{-3}$
- B $0.800 \text{ mol dm}^{-3}$
- C $1.25 \text{ mol}^{-1} \text{ dm}^3$
- D $6.67 \text{ mol}^{-1} \text{ dm}^3$

11 When copper is added to a solution of silver ions, the following equilibrium is established.

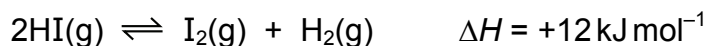


What is the concentration of silver ions at equilibrium when $[\text{Cu}^{2+}] = 0.10 \text{ mol dm}^{-3}$?

- A** $5.0 \times 10^{-7} \text{ mol dm}^{-3}$
- B** $5.0 \times 10^{-4} \text{ mol dm}^{-3}$
- C** $1.0 \times 10^{-3} \text{ mol dm}^{-3}$
- D** $1.0 \times 10^2 \text{ mol dm}^{-3}$

49. Question | 9701 May-June 2019 P1 V1 Q10

- 10** Hydrogen iodide gas decomposes reversibly producing iodine vapour and hydrogen.



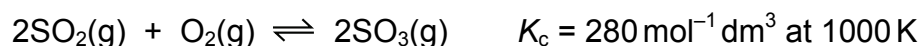
The position of the equilibrium for this reaction may be altered by changing the external conditions.

Which row correctly describes the change in position of equilibrium?

	effect of increasing the pressure	effect of increasing the temperature
A	moves to the right	moves to the right
B	moves to the right	moves to the left
C	no change	moves to the right
D	no change	moves to the left

50. Question | 9701 May-June 2019 P1 V1 Q11

- 11** The reaction between sulfur dioxide and oxygen is reversible.



In an equilibrium mixture at 1000 K the sulfur trioxide concentration is 6.00 mol dm^{-3} .

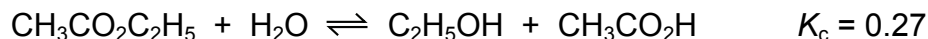
The sulfur dioxide concentration is twice the oxygen concentration.

What is the sulfur dioxide concentration?

- A** $0.175 \text{ mol dm}^{-3}$
- B** $0.254 \text{ mol dm}^{-3}$
- C** $0.318 \text{ mol dm}^{-3}$
- D** $0.636 \text{ mol dm}^{-3}$

51. Question | 9701 May-June 2019 P1 V2 Q10

10 Ethyl ethanoate undergoes the following reaction.



Equal amounts of ethanoic acid and ethanol were mixed together and allowed to reach equilibrium.

At equilibrium, the concentrations of both ethanoic acid and ethanol were 0.42 mol dm^{-3} .

What is the concentration of ethyl ethanoate at equilibrium?

- A** 0.22 mol dm^{-3}
- B** 0.65 mol dm^{-3}
- C** 0.81 mol dm^{-3}
- D** 1.54 mol dm^{-3}

52. Question | 9701 May-June 2019 P1 V2 Q34

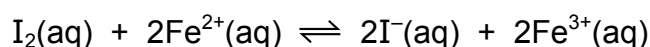
34 The manufacture of ammonia from nitrogen and hydrogen is an important industrial process.

Which of the following would leave the equilibrium constant, K_p , for the formation of ammonia unchanged?

- 1** addition of an iron catalyst
- 2** addition of ammonia
- 3** an increase in pressure

53. Question | 9701 May-June 2019 P1 V3 Q9

9 What is the correct expression for K_c for the reaction shown?



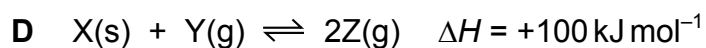
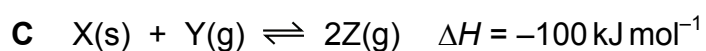
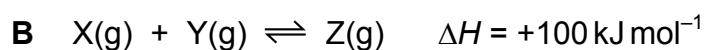
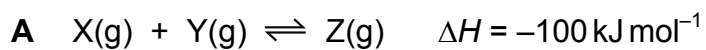
- A** $\frac{[\text{I}_2][2\text{Fe}^{3+}]}{[\text{I}^{-}][2\text{Fe}^{2+}]}$ **B** $\frac{[\text{I}^{-}]^2[\text{Fe}^{3+}]^2}{[\text{I}_2][\text{Fe}^{2+}]^2}$ **C** $\frac{[\text{I}_2][2\text{Fe}^{2+}]}{[\text{I}^{-}][2\text{Fe}^{3+}]}$ **D** $\frac{[\text{I}_2][\text{Fe}^{2+}]^2}{[\text{I}^{-}]^2[\text{Fe}^{3+}]^2}$

10 X and Y react together to form Z in a reversible reaction.

The equilibrium yield of Z is lower at higher temperature.

The equilibrium yield of Z is lower at lower pressure.

Which equation could represent this reaction?

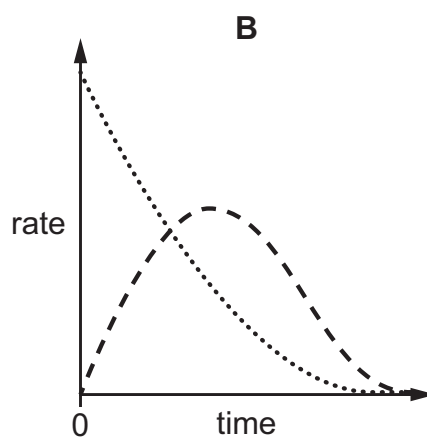
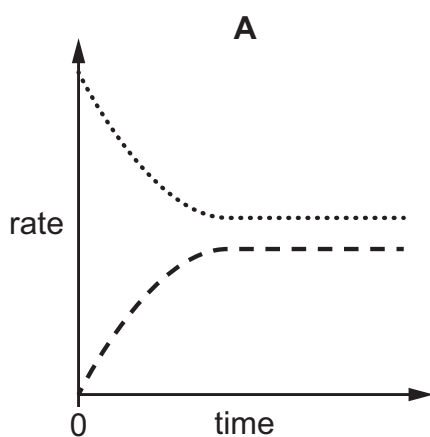


10 Two compounds X and Y react to produce compound Z. The reaction is reversible.



When X and Y are mixed together in a closed system a dynamic equilibrium is gradually established.

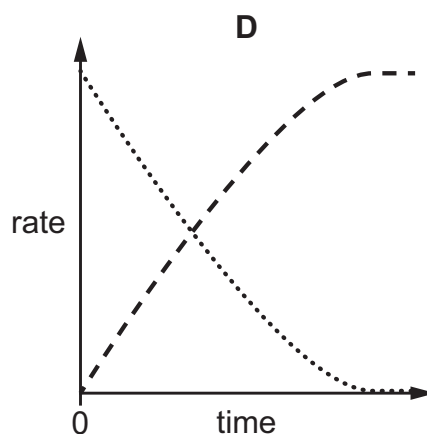
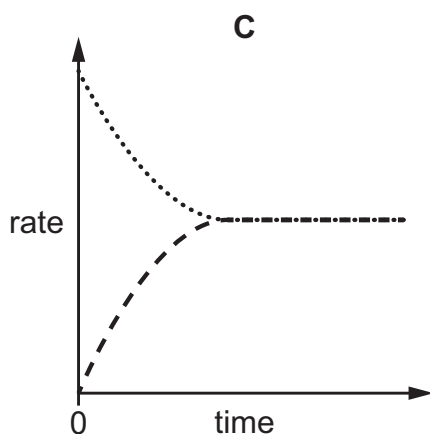
Which graph could represent the change in the rates of the forward and reverse reactions over time?



key

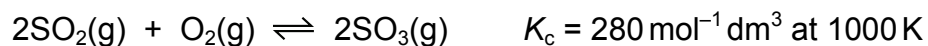
..... rate of
forward
reaction

- - - - - rate of
reverse
reaction



56. Question | 9701 Oct-Nov 2019 P1 V1 Q11

11 The reaction between sulfur dioxide and oxygen is reversible.



In an equilibrium mixture at 1000 K the sulfur dioxide concentration is $0.200 \text{ mol dm}^{-3}$ and the oxygen concentration is $0.100 \text{ mol dm}^{-3}$.

What is the sulfur trioxide concentration?

- A** $1.058 \text{ mol dm}^{-3}$
- B** $1.120 \text{ mol dm}^{-3}$
- C** $2.366 \text{ mol dm}^{-3}$
- D** $5.600 \text{ mol dm}^{-3}$

57. Question | 9701 Oct-Nov 2019 P1 V2 Q10

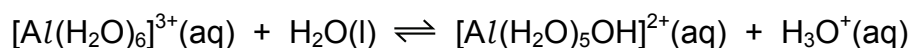
10 The decomposition of $\text{SO}_3(\text{g})$ is a dynamic equilibrium.



What happens when the pressure of the system is increased?

- A** The rate of reaction will decrease and the position of the equilibrium will move to the left.
- B** The rate of reaction will decrease and the position of the equilibrium will move to the right.
- C** The rate of reaction will increase and the position of the equilibrium will move to the left.
- D** The rate of reaction will increase and the position of the equilibrium will move to the right.

11 Hydrated aluminium ions undergo the following reaction.



Which statement about this reaction is correct?

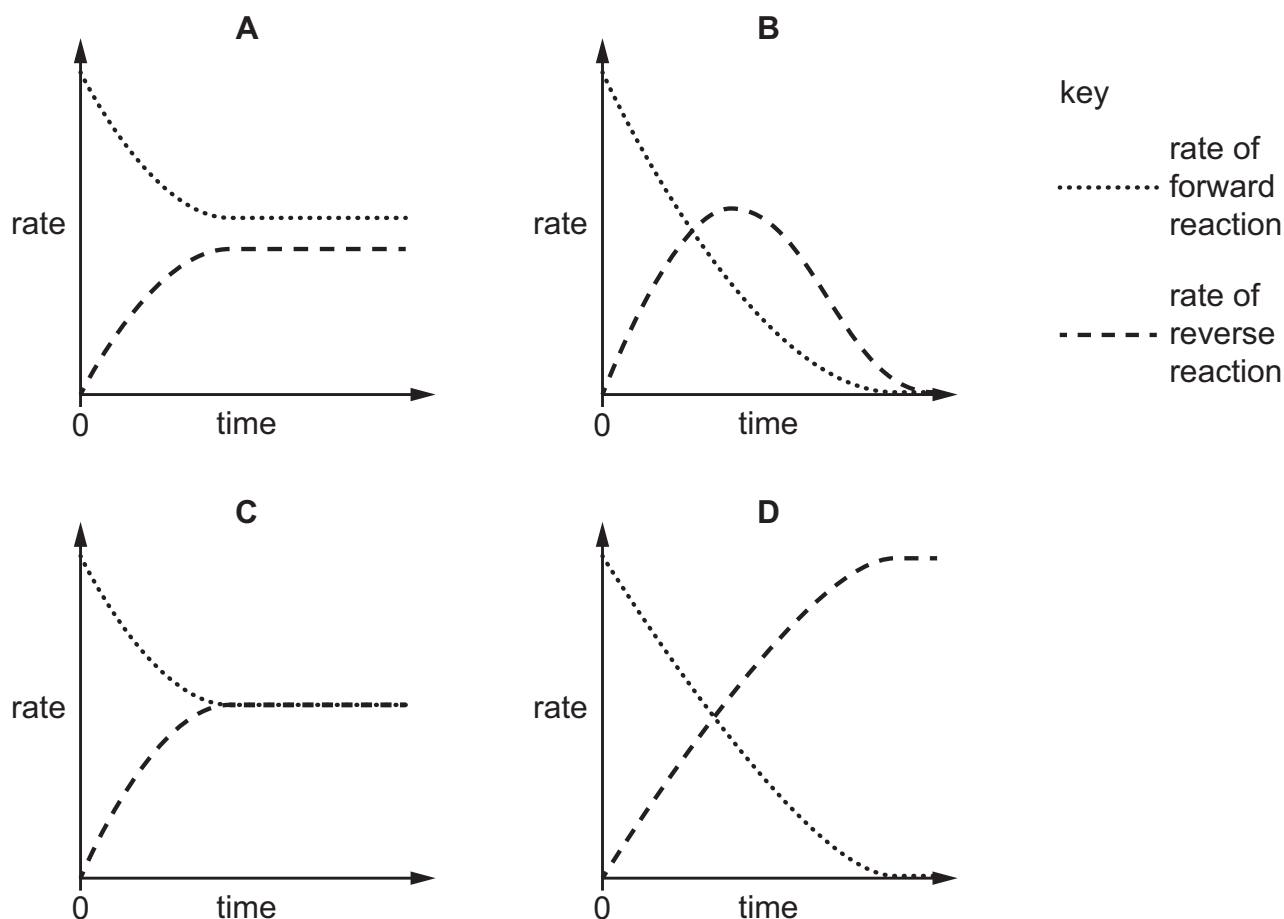
- A** $\text{H}_2\text{O}(\text{l})$ and $[\text{Al}(\text{H}_2\text{O})_5\text{OH}]^{2+}(\text{aq})$ are a conjugate acid-base pair.
- B** $\text{H}_2\text{O}(\text{l})$ is acting as an acid as it is donating H^+ ions.
- C** If $\text{OH}^-(\text{aq})$ is added, the equilibrium will move to the right.
- D** K_c varies as the pH is varied.

10 Two compounds X and Y react to produce compound Z. The reaction is reversible.



When X and Y are mixed together in a closed system a dynamic equilibrium is gradually established.

Which graph could represent the change in the rates of the forward and reverse reactions over time?



60. Question | 9701 Oct-Nov 2019 P1 V3 Q11

11 The reaction between sulfur dioxide and oxygen is reversible.



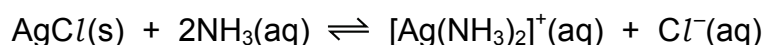
In an equilibrium mixture at 1000 K the sulfur dioxide concentration is $0.200 \text{ mol dm}^{-3}$ and the oxygen concentration is $0.100 \text{ mol dm}^{-3}$.

What is the sulfur trioxide concentration?

- A** $1.058 \text{ mol dm}^{-3}$
- B** $1.120 \text{ mol dm}^{-3}$
- C** $2.366 \text{ mol dm}^{-3}$
- D** $5.600 \text{ mol dm}^{-3}$

61. Question | 9701 Feb-March 2020 P1 V2 Q6

6 The equation for the reaction between silver chloride and aqueous ammonia is shown.

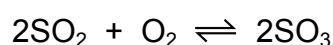


What are the units of K_c for this reaction?

- A** no units
- B** $\text{mol}^{-1} \text{ dm}^3$
- C** mol dm^{-3}
- D** $\text{mol}^2 \text{ dm}^{-6}$

62. Question | 9701 Feb-March 2020 P1 V2 Q11

11 The main stage in the Contact process is an equilibrium reaction.

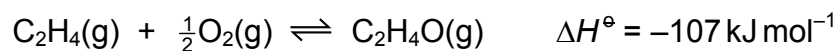


Which row describes the effect of the named condition on the equilibrium yield?

	presence of catalyst	high pressure	high temperature
A	no effect on yield	decreases yield	increases yield
B	no effect on yield	increases yield	decreases yield
C	increases yield	decreases yield	increases yield
D	increases yield	increases yield	decreases yield

63. Question | 9701 May-June 2020 P1 V1 Q1

- 1 Ethene can be oxidised to form epoxyethane, C₂H₄O.

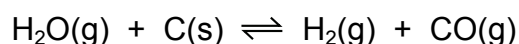


Which set of conditions gives the greatest yield of epoxyethane at equilibrium?

	pressure	temperature / °C
A	high	100
B	high	200
C	low	100
D	low	200

64. Question | 9701 May-June 2020 P1 V1 Q7

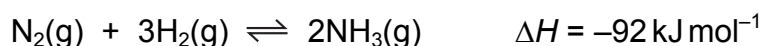
- 7 What are the units of K_p for the reaction shown?



- A** Pa⁻¹ **B** Pa **C** Pa² **D** no units

65. Question | 9701 May-June 2020 P1 V2 Q3

- 3 The catalysed formation of ammonia by the Haber process can be represented by the equation shown.



Which change in conditions will increase both the rate of formation and the equilibrium yield of ammonia?

- A** decrease in the temperature
B increase in the temperature
C increase in the pressure
D increase in the surface area of the catalyst

66. Question | 9701 May-June 2020 P1 V2 Q11

11 PCl_5 decomposes as shown.



1.0 mol of $\text{PCl}_5(\text{g})$, 1.0 mol of $\text{PCl}_3(\text{g})$ and 1.0 mol of $\text{Cl}_2(\text{g})$ are placed in a container of volume 1 dm^3 at 250°C and allowed to reach equilibrium.

At this temperature, the equilibrium mixture contains 1.8 moles of PCl_3 .

What is the value of K_c at 250°C ?

- A** 1 **B** 1.8 **C** 9 **D** 16.2

67. Question | 9701 May-June 2020 P1 V2 Q15

15 Ammonium carbonate is a crystalline solid. On gentle warming a reaction occurs, forming ammonia as one product.

How are the carbonate ions behaving during this reaction?

- A** Brønsted-Lowry acid
B Brønsted-Lowry base
C oxidising agent
D reducing agent

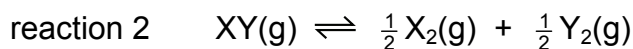
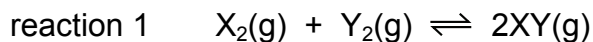
68. Question | 9701 May-June 2020 P1 V3 Q6

6 Which solution has the lowest pH value?

- A** 0.01 mol dm^{-3} butanoic acid
B 0.01 mol dm^{-3} ethanoic acid
C 0.01 mol dm^{-3} hydrochloric acid
D 0.01 mol dm^{-3} sulfuric acid

69. Question | 9701 May-June 2020 P1 V3 Q11

11 Two reactions are shown.



The equilibrium constant, K_p , for reaction 1 is 0.0052.

What is K_p for reaction 2?

- A** 2.6×10^{-3} **B** 13.9 **C** 192.3 **D** 384.6

70. Question | 9701 Oct-Nov 2020 P1 V1 Q10

10 In aqueous solution, sulfuric acid dissociates as shown.



Analysis of a 2.00 mol dm^{-3} solution of H_2SO_4 found the HSO_4^- concentration to be $1.988 \text{ mol dm}^{-3}$.

What is K_c ?

- A** $1.381 \times 10^5 \text{ dm}^3 \text{ mol}^{-1}$
B $82.34 \text{ dm}^3 \text{ mol}^{-1}$
C $1.214 \times 10^{-2} \text{ mol dm}^{-3}$
D $7.244 \times 10^{-5} \text{ mol dm}^{-3}$

71. Question | 9701 Oct-Nov 2020 P1 V1 Q33

33 The units of K_c for an equilibrium reaction are $\text{mol}^{-1} \text{dm}^3$.

What could be the equation for the equilibrium?

- 1** $\text{A(aq)} + \text{B(aq)} \rightleftharpoons \text{C(s)} + \text{D(aq)}$
- 2** $\text{P(aq)} + \text{Q(aq)} \rightleftharpoons \text{R(aq)}$
- 3** $\text{W(aq)} + 2\text{X(aq)} \rightleftharpoons \text{Y(aq)} + \text{Z(aq)}$

72. Question | 9701 Oct-Nov 2020 P1 V2 Q10

10 Sulfur dioxide and oxygen react to form sulfur trioxide. The reaction is reversible.



The reaction is allowed to reach equilibrium at 700°C . The partial pressure of $\text{O}_2(\text{g})$ is 375 kPa and the partial pressure of $\text{SO}_3(\text{g})$ is 20.3 kPa.

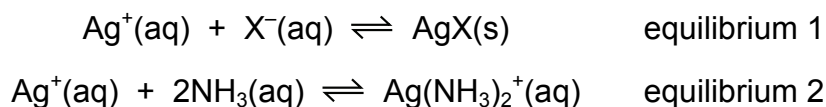
What is the partial pressure of $\text{SO}_2(\text{g})$?

- A** 19.3 kPa **B** 609 kPa **C** 18 300 kPa **D** 609 000 kPa

73. Question | 9701 Oct-Nov 2020 P1 V2 Q14

14 $\text{AgNO}_3(\text{aq})$ is added to a solution of a halide ion, $\text{X}^-(\text{aq})$, and aqueous ammonia is then added.

The ionic equations for the two reactions that occur are shown.



Which statement is correct?

- A** The position of equilibrium 1 lies to the left when $\text{X}^- = \text{I}^-$.
- B** Increasing the concentration of ammonia causes the position of equilibrium 1 to move to the left.
- C** K_c for equilibrium 2 is larger when $\text{X}^- = \text{Cl}^-$ than when $\text{X}^- = \text{I}^-$.
- D** Equilibrium 2 is a redox reaction.

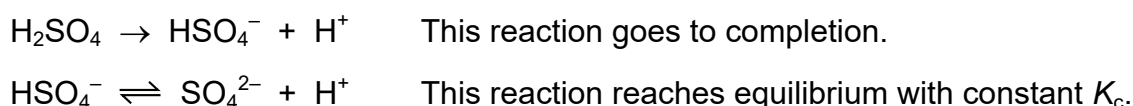
74. Question | 9701 Oct-Nov 2020 P1 V2 Q34

34 Which statements about a reaction that has reached dynamic equilibrium are correct?

- 1** The rate of the forward reaction equals the rate of the reverse reaction.
- 2** There is no overall change in the concentrations of reactants and products.
- 3** There is no change in the measurable properties of the system.

75. Question | 9701 Oct-Nov 2020 P1 V3 Q10

10 In aqueous solution, sulfuric acid dissociates as shown.



Analysis of a 2.00 mol dm^{-3} solution of H_2SO_4 found the HSO_4^- concentration to be $1.988 \text{ mol dm}^{-3}$.

What is K_c ?

- A** $1.381 \times 10^5 \text{ dm}^3 \text{ mol}^{-1}$
- B** $82.34 \text{ dm}^3 \text{ mol}^{-1}$
- C** $1.214 \times 10^{-2} \text{ mol dm}^{-3}$
- D** $7.244 \times 10^{-5} \text{ mol dm}^{-3}$

76. Question | 9701 Oct-Nov 2020 P1 V3 Q33

33 The units of K_c for an equilibrium reaction are $\text{mol}^{-1} \text{dm}^3$.

What could be the equation for the equilibrium?

- 1** $\text{A(aq)} + \text{B(aq)} \rightleftharpoons \text{C(s)} + \text{D(aq)}$
- 2** $\text{P(aq)} + \text{Q(aq)} \rightleftharpoons \text{R(aq)}$
- 3** $\text{W(aq)} + 2\text{X(aq)} \rightleftharpoons \text{Y(aq)} + \text{Z(aq)}$

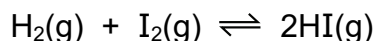
77. Question | 9701 Feb-March 2021 P1 V2 Q9

9 In which reaction is water behaving as a Brønsted–Lowry base?

- A** $\text{H}_2\text{O} + \text{Na} \rightarrow \text{NaOH} + \frac{1}{2}\text{H}_2$
- B** $\text{H}_2\text{O} + \text{H}_3\text{PO}_4 \rightarrow \text{H}_3\text{O}^+ + \text{H}_2\text{PO}_4^-$
- C** $\text{H}_2\text{O} + \text{CaO} \rightarrow \text{Ca(OH)}_2$
- D** $\text{NH}_3 + [\text{Cu(H}_2\text{O)}_6]^{2+} \rightarrow \text{NH}_4^+ + [\text{Cu(H}_2\text{O)}_5(\text{OH})]^+$

78. Question | 9701 Feb-March 2021 P1 V2 Q31

31 A sample of 17.15 mol HI(g) is in dynamic equilibrium with 2.27 mol H₂(g) and 2.84 mol I₂(g) in a volume of 1 m³ at 764 K and 141 kPa.

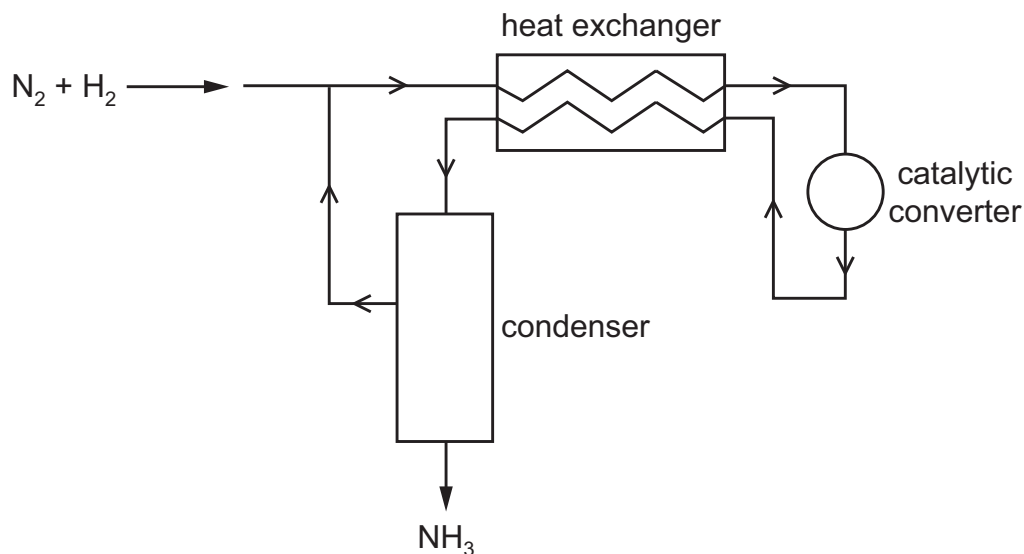


Two equilibrium constants, K_c and K_p , can be calculated for this mixture.

Which statements about the equilibrium constants for this mixture are correct?

- 1** neither K_c nor K_p has any units
- 2** $K_c = 45.6$
- 3** $K_c > K_p$

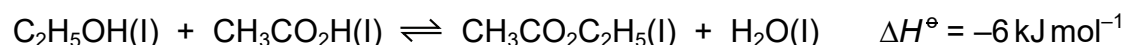
- 10** The diagram represents the Haber process for the manufacture of ammonia from nitrogen and hydrogen.



What is the purpose of the heat exchanger?

- A** to cool the incoming gas mixture to avoid overheating the catalyst
- B** to cool the reaction products and separate the NH_3 from unused N_2 and H_2
- C** to warm the incoming gas mixture and shift the equilibrium to give more NH_3
- D** to warm the incoming gas mixture and speed up the reaction

31 Ethanol combines with ethanoic acid to form ethyl ethanoate according to the following reaction.



9.2 g ethanol, 12 g ethanoic acid and 8.8 g ethyl ethanoate are mixed and allowed to stand at 298 K, until equilibrium is reached.

(M_r : $\text{C}_2\text{H}_5\text{OH}$, 46; $\text{CH}_3\text{CO}_2\text{H}$, 60; $\text{CH}_3\text{CO}_2\text{C}_2\text{H}_5$, 88)

The resulting equilibrium mixture is found to contain 4.8 g ethanoic acid.

The experiment is repeated at 323 K.

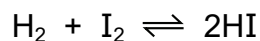
Which statements are correct?

- 1** There are 0.22 moles of ethyl ethanoate in the mixture at equilibrium at 298 K.
- 2** The equilibrium mixture at 323 K will contain more than 4.8 g of ethanoic acid.
- 3** If a small amount of water is added at the start of either experiment the value of K_c would not be affected.

81. Question | 9701 May-June 2021 P1 V2 Q10

- 10** 3.60 moles of hydrogen gas and 2.00 moles of iodine vapour are placed in a reaction vessel which is then sealed and maintained at a constant temperature.

The equation for the reaction is shown.



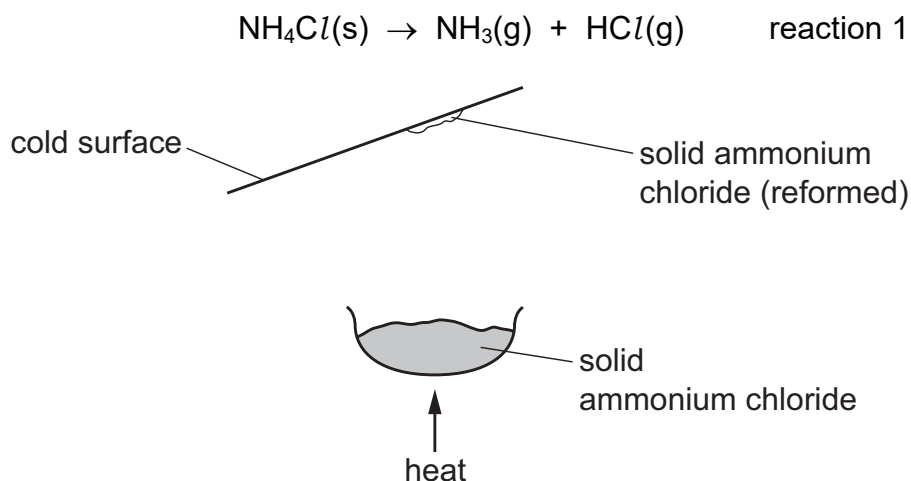
At equilibrium, 3.20 moles of hydrogen remain. All reactants and products are gaseous.

What is the value of K_p under these conditions?

- A** 0.0313 **B** 0.125 **C** 0.156 **D** 8.00

82. Question | 9701 May-June 2021 P1 V2 Q33

- 33** When a sample of ammonium chloride is warmed it decomposes into ammonia and hydrogen chloride gas.

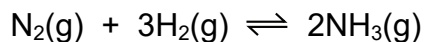


When the mixture of hot ammonia and hydrogen chloride gases hit a cold surface, a white solid of ammonium chloride reforms.

Which statements are correct?

- 1** Reaction 1 is in dynamic equilibrium.
- 2** Reaction 1 is reversible.
- 3** Reaction 1 is an endothermic reaction.

10 Nitrogen reacts with hydrogen to produce ammonia.



A mixture of 2.00 mol of nitrogen, 6.00 mol of hydrogen and 2.40 mol of ammonia is allowed to reach equilibrium in a sealed vessel of volume 1 dm^3 . It is found that 2.32 mol of nitrogen were present in the equilibrium mixture.

Which expression will give the value of K_c ?

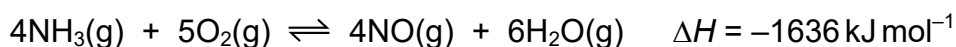
A $\frac{(1.76)^2}{(2.32)(6.96)^3}$

B $\frac{(1.76)^2}{(2.32)(6.32)^3}$

C $\frac{(2.08)^2}{(2.32)(6.32)^3}$

D $\frac{(2.40)^2}{(2.32)(6.00)^3}$

11 Nitric acid is produced by oxidising ammonia. The first step is to react ammonia with oxygen in the presence of a catalyst to form nitrogen monoxide.



Which set of conditions will produce the greatest yield of nitrogen monoxide at equilibrium?

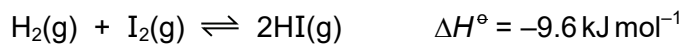
	temperature	pressure
A	high	high
B	high	low
C	low	high
D	low	low

- 13** Ammonia exists as simple covalent molecules, NH_3 . Ammonia can react with suitable reagents to form products containing ammonium ions, NH_4^+ . Ammonia can also react with suitable reagents to form products containing amide ions, NH_2^- .

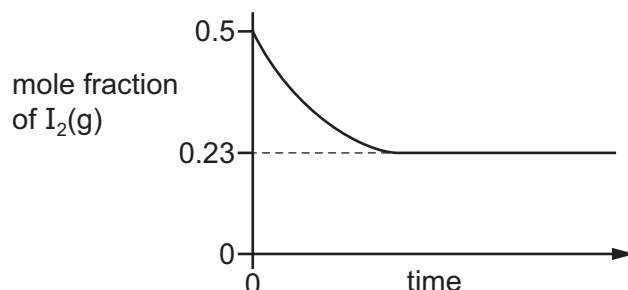
Which of these nitrogen-containing species are present in an aqueous solution of ammonia?

- A** ammonia molecules and amide ions
- B** ammonia molecules and ammonium ions
- C** ammonia molecules only
- D** ammonium ions only

10 The equation shows that $\text{H}_2(\text{g})$ and $\text{I}_2(\text{g})$ react to form an equilibrium mixture.



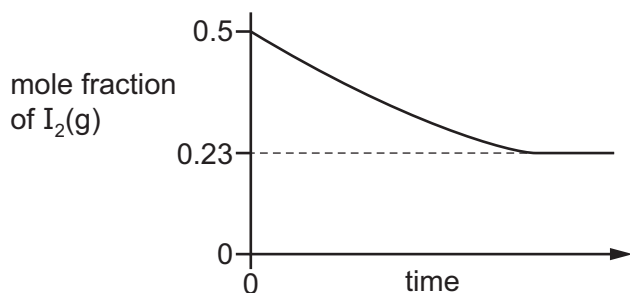
A mixture containing equal amounts of $\text{H}_2(\text{g})$ and $\text{I}_2(\text{g})$ is made at temperature T_1 and the composition of the mixture is monitored. A graph of the results is shown.



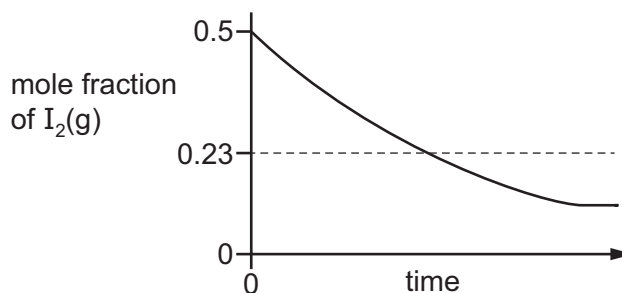
The experiment is repeated at a lower temperature, T_2 .

Which new graph would be obtained?

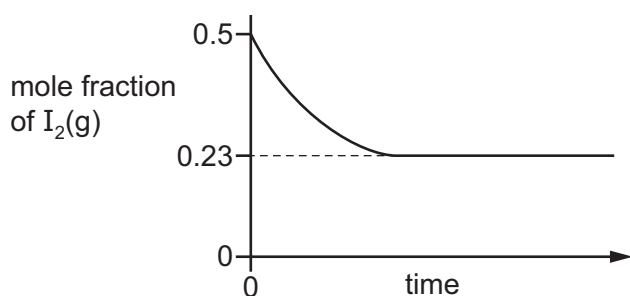
A



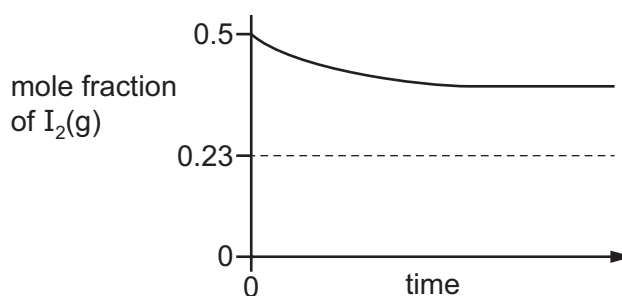
B



C

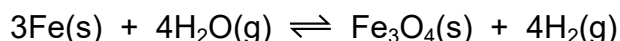


D



87. Question | 9701 Oct-Nov 2021 P1 V1 Q32

32 Iron reacts with steam to produce hydrogen and an oxide of iron.



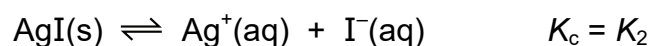
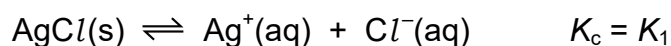
A system containing all four substances is at equilibrium.

Which changes will decrease the mass of Fe present at equilibrium?

- 1 addition of steam at constant pressure
- 2 increase in overall pressure
- 3 addition of an effective catalyst

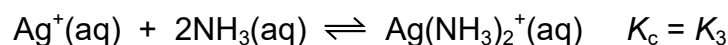
88. Question | 9701 Oct-Nov 2021 P1 V2 Q16

16 Silver chloride and silver iodide form equilibria when added to water.



Each equilibrium position lies well to the **left**.

Silver iodide will not dissolve in aqueous ammonia. Silver chloride will dissolve in aqueous ammonia. Another equilibrium is formed.



The position of this equilibrium lies to the **right**.

What is the order of magnitude for these three equilibrium constants?

	smallest	→	largest
A	K_3	K_2	K_1
B	K_3	K_1	K_2
C	K_2	K_1	K_3
D	K_1	K_2	K_3

89. Question | 9701 Oct-Nov 2021 P1 V2 Q19

- 19** Magnesium hydroxide dissolves in aqueous ammonium chloride, but not in aqueous sodium chloride.

Which statement explains this observation?

- A** The ionic radius of the NH_4^+ ion is similar to that of Mg^{2+} but not that of Na^+ .
- B** NH_4Cl dissociates less fully than NaCl .
- C** The Na^+ and Mg^{2+} ions have the same number of electrons.
- D** The NH_4^+ ion can donate a proton.

90. Question | 9701 Oct-Nov 2021 P1 V2 Q32

- 32** Four solutions, each of concentration 0.1 mol dm^{-3} , were tested with a pH meter. The results are shown.

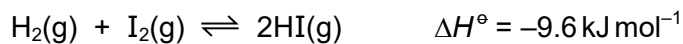
solution	formula of acid or base	pH
acid 1	$\text{CH}_3\text{CO}_2\text{H}$	4
acid 2	HNO_3	1
base 1	CH_3NH_2	11
base 2	NaOH	14

Which statements explain these results?

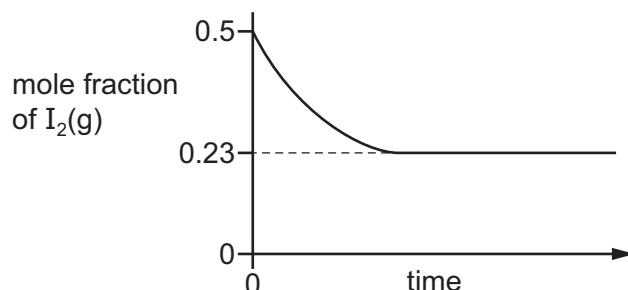
- 1** Acid 2 has a lower pH than acid 1 because it is more soluble.
- 2** Base 2 has a higher concentration of hydroxide ions in solution than base 1.
- 3** Acid 1 dissociates less than acid 2.

91. Question | 9701 Oct-Nov 2021 P1 V3 Q10

10 The equation shows that $\text{H}_2(\text{g})$ and $\text{I}_2(\text{g})$ react to form an equilibrium mixture.

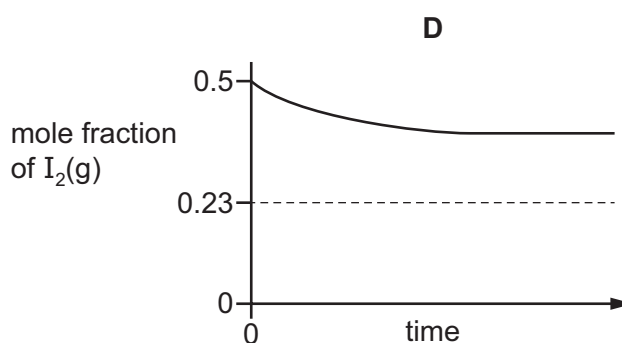
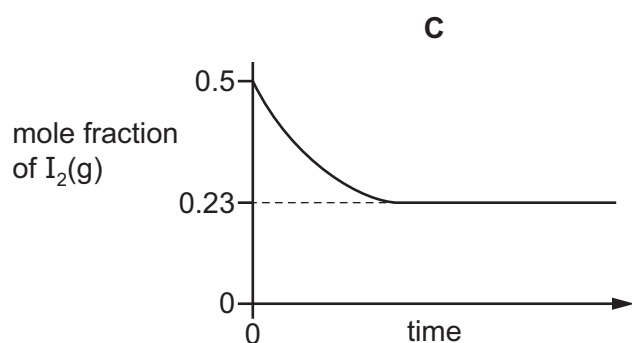
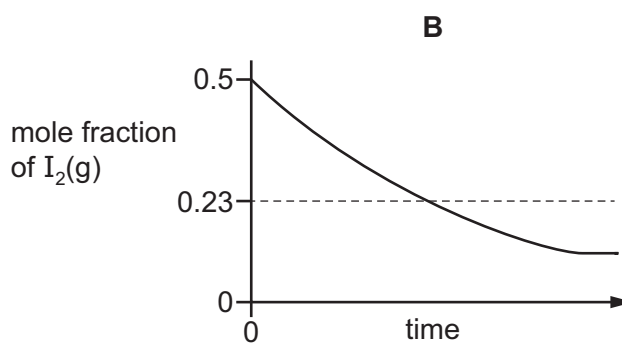
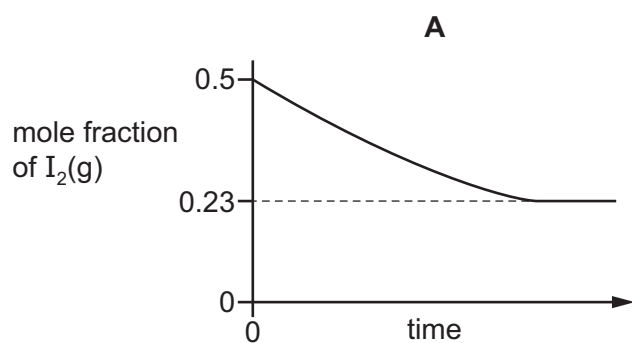


A mixture containing equal amounts of $\text{H}_2(\text{g})$ and $\text{I}_2(\text{g})$ is made at temperature T_1 and the composition of the mixture is monitored. A graph of the results is shown.



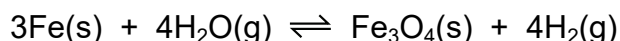
The experiment is repeated at a lower temperature, T_2 .

Which new graph would be obtained?



92. Question | 9701 Oct-Nov 2021 P1 V3 Q32

32 Iron reacts with steam to produce hydrogen and an oxide of iron.



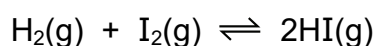
A system containing all four substances is at equilibrium.

Which changes will decrease the mass of Fe present at equilibrium?

- 1** addition of steam at constant pressure
- 2** increase in overall pressure
- 3** addition of an effective catalyst

93. Question | 9701 Feb-March 2022 P1 V2 Q12

12 Hydrogen and iodine react to form hydrogen iodide in an exothermic reaction. The equation is shown.



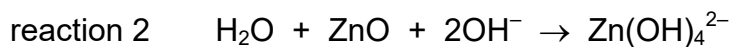
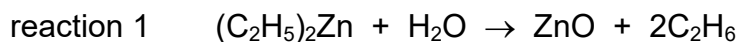
A 1 m^3 reaction vessel contains H_2 , I_2 and HI gases at equilibrium. The temperature is changed such that the total pressure in the 1 m^3 vessel doubles.

What is the effect on the value of K_p and on the position of equilibrium?

	effect on the value of K_p	effect on the position of equilibrium
A	decreases	moves left
B	increases	moves right
C	no change	moves left
D	no change	no change

94. Question | 9701 Feb-March 2022 P1 V2 Q13

13 Diethylzinc, $(\text{C}_2\text{H}_5)_2\text{Zn}$, is added to $\text{NaOH}(\text{aq})$. Two reactions occur.



In these reactions, which compounds act as Brønsted–Lowry acids?

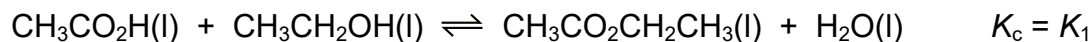
	reaction 1	reaction 2
A	$(\text{C}_2\text{H}_5)_2\text{Zn}$	H_2O
B	H_2O	H_2O
C	H_2O	ZnO
D	the reaction is not acid / base	ZnO

95. Question | 9701 May-June 2022 P1 V1 Q13

13 Ethanoic acid is mixed with ethanol.

The ethanol is contaminated with a small amount of methanol.

The following equilibria are established.



Which statement about the equilibrium mixture is correct?

- A** Only ethyl ethanoate will be formed because there is much more ethanol present than methanol.
- B** In this mixture $\frac{[\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_3]}{[\text{CH}_3\text{CO}_2\text{CH}_3]} = \frac{K_1}{K_2}$.
- C** Adding water to the mixture will alter the mole ratio of the two esters.
- D** Adding methyl ethanoate to the mixture will increase the number of moles of ethyl ethanoate.

14 SO_3 is manufactured from SO_2 and O_2 in the Contact process.

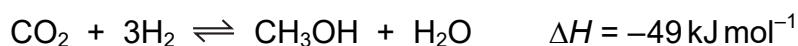
The reaction is exothermic.

Which row shows the effect on the equilibrium yield obtained in the Contact process of increasing the temperature and of adding a vanadium(V) oxide catalyst?

	increasing the temperature	adding vanadium(V) oxide as catalyst
A	equilibrium yield decreases	equilibrium yield increases
B	equilibrium yield decreases	equilibrium yield unchanged
C	equilibrium yield increases	equilibrium yield unchanged
D	equilibrium yield increases	equilibrium yield increases

97. Question | 9701 May-June 2022 P1 V2 Q13

13 A synthesis for methanol is shown.

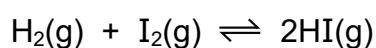


Which conditions would produce the greatest yield of methanol at equilibrium?

	pressure	temperature / °C
A	high	80
B	high	20
C	low	80
D	low	20

98. Question | 9701 May-June 2022 P1 V2 Q14

14 Hydrogen and iodine can react reversibly to produce hydrogen iodide. The equation is shown.



4.00 mol of hydrogen gas and X mol of iodine vapour are mixed in a sealed container of volume 1.00 dm³ at a temperature of 460 K. The system is allowed to reach equilibrium.

The equilibrium mixture contains 2.00 mol of hydrogen iodide. The equilibrium constant, K_c , for the reaction at 460 K is 4.0.

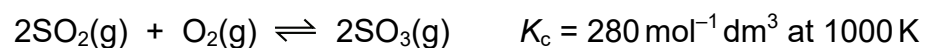
What is the value of X?

- A** 0.50 mol **B** 1.17 mol **C** 1.33 mol **D** 2.50 mol

13 Which statement about acids and bases is **always** correct?

- A** An acid with two H atoms per molecule will be stronger than an acid with one H atom per molecule.
- B** A concentrated solution of a strong acid will have a lower pH than a dilute solution of a weak acid.
- C** A concentrated solution of a strong base will have a lower pH than a dilute solution of a weak base.
- D** A strong acid is more dissociated in solution than a strong base.

14 The reaction between sulfur dioxide and oxygen is reversible.



In an equilibrium mixture at 1000 K the sulfur trioxide concentration is 6.00 mol dm^{-3} .

The sulfur dioxide concentration is twice the oxygen concentration.

What is the sulfur dioxide concentration?

- A** $0.175 \text{ mol dm}^{-3}$
- B** $0.252 \text{ mol dm}^{-3}$
- C** $0.318 \text{ mol dm}^{-3}$
- D** $0.636 \text{ mol dm}^{-3}$

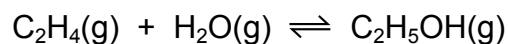
101. Question | 9701 Oct-Nov 2022 P1 V1 Q13

13 In which equilibrium reaction is the position of equilibrium moved to the right-hand side by increasing the temperature and also by decreasing the pressure?

- A** $\text{H}_2(\text{g}) + \text{CO}_2(\text{g}) \rightleftharpoons \text{H}_2\text{O}(\text{g}) + \text{CO}(\text{g}) \quad \Delta H = 40 \text{ kJ mol}^{-1}$
- B** $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g}) \quad \Delta H = 58 \text{ kJ mol}^{-1}$
- C** $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g}) \quad \Delta H = -197 \text{ kJ mol}^{-1}$
- D** $2\text{HI}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{I}_2(\text{g}) \quad \Delta H = -10 \text{ kJ mol}^{-1}$

102. Question | 9701 Oct-Nov 2022 P1 V1 Q14

14 Ethanol is produced industrially by reacting ethene and steam.



K_p has a value of 1.8×10^{-5} and the partial pressures of the reactants at equilibrium are shown.

reactant	partial pressure / kPa
ethene	4.8×10^3
steam	2.8×10^3

Which row is correct?

	partial pressure of ethanol at equilibrium / kPa	units of K_p
A	2.42×10^2	kPa^{-1}
B	2.42×10^2	kPa
C	7.47×10^{11}	kPa^{-1}
D	7.47×10^{11}	kPa

- 7** Hydrogen peroxide decomposes slowly at 20 °C to form water and oxygen.

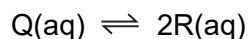


The reaction is faster when a catalyst is present.

Which statement is correct?

- A** The catalyst alters the Boltzmann distribution so that the reactant molecules have more energy.
- B** The catalyst has no effect on the value of K_c .
- C** The catalyst increases the value of K_c .
- D** The catalyst provides a different reaction mechanism with a higher activation energy.

- 8 A dimer, Q, is stable when solid but a dynamic equilibrium is set up in solution.



A solution of Q has an initial concentration of 0.50 mol dm^{-3} . When equilibrium has been reached, $[\text{Q(aq)}]$ has fallen to 0.25 mol dm^{-3} .

The changes in $[\text{Q(aq)}]$ and $[\text{R(aq)}]$ are plotted against time until equilibrium is reached. The value of K_c is then calculated.

Which graph and value for K_c are correct?

	graph	$K_c / \text{mol dm}^{-3}$
A	concentration / mol dm^{-3} time	1
B	concentration / mol dm^{-3} time	0.25
C	concentration / mol dm^{-3} time	1
D	concentration / mol dm^{-3} time	2

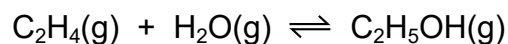
105. Question | 9701 Oct-Nov 2022 P1 V3 Q13

13 In which equilibrium reaction is the position of equilibrium moved to the right-hand side by increasing the temperature and also by decreasing the pressure?

- A** $\text{H}_2(\text{g}) + \text{CO}_2(\text{g}) \rightleftharpoons \text{H}_2\text{O}(\text{g}) + \text{CO}(\text{g})$ $\Delta H = 40 \text{ kJ mol}^{-1}$
- B** $\text{N}_2\text{O}_4(\text{g}) \rightleftharpoons 2\text{NO}_2(\text{g})$ $\Delta H = 58 \text{ kJ mol}^{-1}$
- C** $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$ $\Delta H = -197 \text{ kJ mol}^{-1}$
- D** $2\text{HI}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{I}_2(\text{g})$ $\Delta H = -10 \text{ kJ mol}^{-1}$

106. Question | 9701 Oct-Nov 2022 P1 V3 Q14

14 Ethanol is produced industrially by reacting ethene and steam.



K_p has a value of 1.8×10^{-5} and the partial pressures of the reactants at equilibrium are shown.

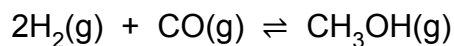
reactant	partial pressure / kPa
ethene	4.8×10^3
steam	2.8×10^3

Which row is correct?

	partial pressure of ethanol at equilibrium / kPa	units of K_p
A	2.42×10^2	kPa^{-1}
B	2.42×10^2	kPa
C	7.47×10^{11}	kPa^{-1}
D	7.47×10^{11}	kPa

107. Question | 9701 Specimen 2022 P1 Q12

12 Methanol can be produced from hydrogen and carbon monoxide.



What is the expression for K_p for this reaction?

A $K_p = \frac{2p_{\text{H}_2}^2 \times p_{\text{CO}}}{p_{\text{CH}_3\text{OH}}}$

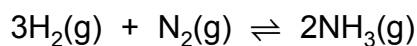
B $K_p = \frac{p_{\text{H}_2}^2 \times p_{\text{CO}}}{p_{\text{CH}_3\text{OH}}}$

C $K_p = \frac{p_{\text{CH}_3\text{OH}}}{p_{\text{H}_2}^2 \times p_{\text{CO}}}$

D $K_p = \frac{p_{\text{CH}_3\text{OH}}}{2p_{\text{H}_2}^2 \times p_{\text{CO}}}$

108. Question | 9701 Feb-March 2023 P1 V2 Q4

4 The table shows the partial pressures in an equilibrium mixture formed by the Haber process.



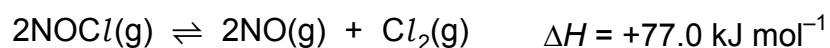
substance	partial pressure / kPa
nitrogen	7000
hydrogen	8000
ammonia	4000

What is the numerical value of the equilibrium constant, K_p , for this reaction?

A 4.46×10^{-9} **B** 4.76×10^{-5} **C** 7.14×10^{-5} **D** 2.24×10^8

109. Question | 9701 Feb-March 2023 P1 V2 Q5

- 5** A reversible reaction is shown.



Which change in conditions will move the position of equilibrium to the right and increase the value of the equilibrium constant?

- A** a decrease in pressure
- B** a decrease in temperature
- C** an increase in pressure
- D** an increase in temperature

110. Question | 9701 May-June 2023 P1 V1 Q4

- 4** For which equilibrium do both of the equilibrium constants K_c and K_p have no units?

- A** $\text{H}_2\text{(g)} + \text{I}_2\text{(g)} \rightleftharpoons 2\text{HI(g)}$
- B** $\text{N}_2\text{(g)} + 3\text{H}_2\text{(g)} \rightleftharpoons 2\text{NH}_3\text{(g)}$
- C** $\text{N}_2\text{O}_4\text{(g)} \rightleftharpoons 2\text{NO}_2\text{(g)}$
- D** $\text{SO}_2\text{(g)} + \frac{1}{2}\text{O}_2\text{(g)} \rightleftharpoons \text{SO}_3\text{(g)}$

111. Question | 9701 May-June 2023 P1 V1 Q8

- 8** The Contact process takes place at a pressure between 100 000 Pa and 200 000 Pa. A catalyst is used.

Which statement is correct?

- A** A V_2O_5 catalyst is added to increase the equilibrium yield of the reaction.
- B** Changes in pressure have no effect on the position of equilibrium.
- C** The equilibrium yield of the reaction is very high under the conditions used.
- D** An iron catalyst is added to increase the rate of reaction.

112. Question | 9701 May-June 2023 P1 V2 Q13

- 13** In which equilibrium will an increase in pressure at constant temperature increase the yield of the products on the right-hand side of the equation?

- A** $\text{CaCO}_3(\text{s}) \rightleftharpoons \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$
- B** $4\text{HCl}(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{H}_2\text{O}(\text{g}) + 2\text{Cl}_2(\text{g})$
- C** $2\text{HI}(\text{g}) \rightleftharpoons \text{H}_2(\text{g}) + \text{I}_2(\text{g})$
- D** $3\text{Fe}(\text{s}) + 4\text{H}_2\text{O}(\text{g}) \rightleftharpoons \text{Fe}_3\text{O}_4(\text{s}) + 4\text{H}_2(\text{g})$

113. Question | 9701 May-June 2023 P1 V2 Q14

- 14** Hydrogen iodide is added to an evacuated reaction vessel. The vessel is sealed and warmed. A decomposition reaction occurs. Hydrogen and iodine are formed. Some hydrogen iodide remains.

When equilibrium is established, the total pressure is 1.20×10^5 Pa. The partial pressure of hydrogen is 4.00×10^3 Pa.

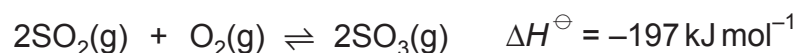
Hydrogen iodide, hydrogen and iodine are all gaseous under the conditions used.

What is the value of K_p for the equilibrium at this temperature, assuming the decomposition is the forward reaction?

- A** 1.19×10^{-3} **B** 1.28×10^{-3} **C** 1.38×10^{-3} **D** 1.43×10^{-3}

114. Question | 9701 May-June 2023 P1 V3 Q15

- 15** Sulfur dioxide reacts with oxygen as shown.

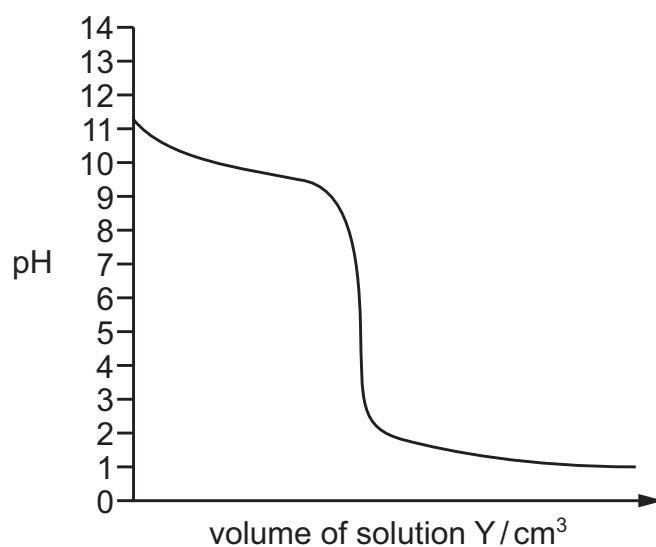


Which change will move the equilibrium position to the right side and change the value of the equilibrium constant, K_c ?

- A** the addition of a catalyst
B increasing the pressure of the reaction
C decreasing the temperature of the reaction
D decreasing the concentration of product

- 16** Solutions X and Y both have a concentration of 0.10 mol dm^{-3} . A fixed volume of solution X is added to a conical flask, and solution Y is added from a burette to the conical flask. A titration is performed.

The diagram shows the pH titration curve for the acid–base reaction between the solutions.



What are solutions X and Y?

	solution X	solution Y
A	ammonia	nitric acid
B	ammonia	ethanoic acid
C	potassium hydroxide	nitric acid
D	potassium hydroxide	ethanoic acid

116. Question | 9701 Oct-Nov 2023 P1 V1 Q12

- 12** Nitrogen dioxide, NO_2 , exists in equilibrium with dinitrogen tetroxide, N_2O_4 .



Which conditions give the greatest percentage of $\text{N}_2\text{O}_4(\text{g})$ at equilibrium?

	pressure	temperature
A	high	high
B	high	low
C	low	high
D	low	low

117. Question | 9701 Oct-Nov 2023 P1 V1 Q13

- 13** When an equimolar mixture of H_2 and I_2 react, the mole fraction of HI in the final mixture is x .

What is the equilibrium constant, K_p , for the reaction?

- A** $\frac{x^2}{(1-x)^2}$
- B** $\frac{x^2}{(1-2x)^2}$
- C** $\frac{4x^2}{(1-x)^2}$
- D** $\frac{4x^2}{(1-2x)^2}$

118. Question | 9701 Oct-Nov 2023 P1 V2 Q15

- 15** 0.200 mol of sulfur dioxide and 0.200 mol of oxygen are placed in a 1.00 dm^3 sealed container. The gases are allowed to react until equilibrium is reached.



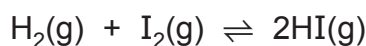
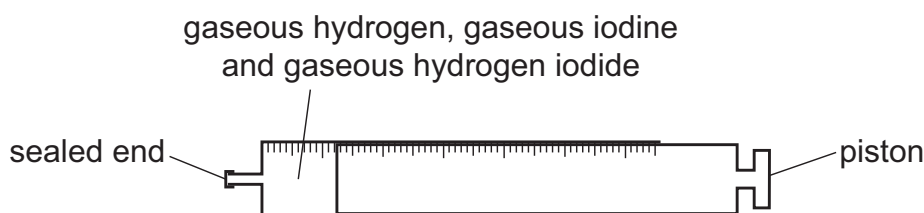
At equilibrium there is 0.100 mol of SO_3 in the container.

What is the value of K_c ?

- A** $0.150 \text{ mol dm}^{-3}$
- B** $0.800 \text{ mol dm}^{-3}$
- C** $1.25 \text{ mol}^{-1} \text{ dm}^3$
- D** $6.67 \text{ mol}^{-1} \text{ dm}^3$

119. Question | 9701 Oct-Nov 2023 P1 V2 Q17

- 17** The diagram shows a gas syringe with a free-moving piston. The syringe contains gaseous hydrogen, gaseous iodine and gaseous hydrogen iodide at equilibrium.



Three changes are listed.

- 1 increasing the total pressure by adding an inert gas and keeping the volume constant
- 2 increasing the pressure by adding more gaseous hydrogen iodide and keeping the volume constant
- 3 decreasing the volume by pushing the piston to the left

Which changes will result in an equilibrium position at which the rate of the forward reaction has increased?

- A** 2 only
- B** 1 and 2
- C** 1 and 3
- D** 2 and 3

120. Question | 9701 Oct-Nov 2023 P1 V2 Q26

26 NaOH(aq) is added to NH_4Cl (aq). The mixture is warmed.

The gas that is produced turns damp red litmus paper blue.

Which row is correct?

	behaviour of the ammonium ion in NH_4Cl	behaviour of the water present on the litmus paper
A	Brønsted–Lowry acid	Brønsted–Lowry base
B	Brønsted–Lowry acid	Brønsted–Lowry acid
C	Brønsted–Lowry base	Brønsted–Lowry acid
D	Brønsted–Lowry base	Brønsted–Lowry base

121. Question | 9701 Oct-Nov 2023 P1 V3 Q12

12 Nitrogen dioxide, NO_2 , exists in equilibrium with dinitrogen tetroxide, N_2O_4 .



Which conditions give the greatest percentage of $\text{N}_2\text{O}_4(\text{g})$ at equilibrium?

	pressure	temperature
A	high	high
B	high	low
C	low	high
D	low	low

13 When an equimolar mixture of H_2 and I_2 react, the mole fraction of HI in the final mixture is x .

What is the equilibrium constant, K_p , for the reaction?

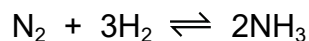
A
$$\frac{x^2}{(1-x)^2}$$

B
$$\frac{x^2}{(1-2x)^2}$$

C
$$\frac{4x^2}{(1-x)^2}$$

D
$$\frac{4x^2}{(1-2x)^2}$$

- 13** Nitrogen and hydrogen are mixed in a reaction vessel. The reaction reaches equilibrium giving a mixture of nitrogen, hydrogen and ammonia gases.



The mixture of gases present at equilibrium at a total pressure of 300 atm is shown.

gas	number of mol in mixture
nitrogen	180
hydrogen	590
ammonia	160

What is the equilibrium constant, K_p , for the forward reaction?

- A** $6.65 \times 10^{-6} \text{ atm}^{-2}$
- B** $7.13 \times 10^{-5} \text{ atm}^{-2}$
- C** 0.599 atm^{-2}
- D** $1.50 \times 10^5 \text{ atm}^2$

124. Question | 9701 Feb-March 2024 P1 V2 Q14

- 14** A mixture of hydrogen gas and iodine gas is placed in a reaction vessel of volume V at temperature T .

The reaction $\text{H}_2 + \text{I}_2 \rightleftharpoons 2\text{HI}$ is allowed to come to equilibrium.

All substances remain in the gaseous state.

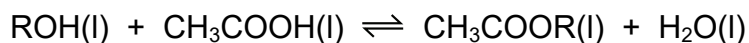
Argon gas is then pumped into the reaction vessel. The temperature in the vessel is maintained at T .

How are the rate of the forward reaction and the partial pressure of HI at equilibrium affected?

	rate of forward reaction	partial pressure of HI at equilibrium
A	increased	increased
B	increased	unaffected
C	unaffected	increased
D	unaffected	unaffected

125. Question | 9701 May-June 2024 P1 V1 Q13

- 13** An alcohol, ROH, reacts reversibly with ethanoic acid to produce an ester.



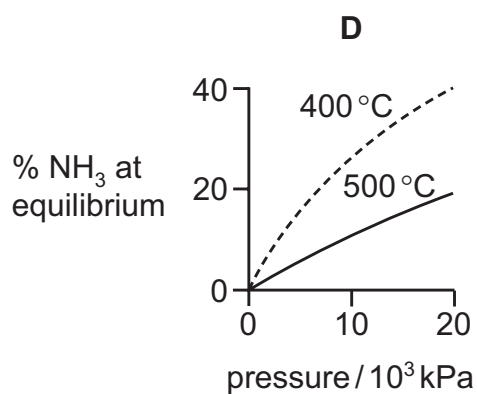
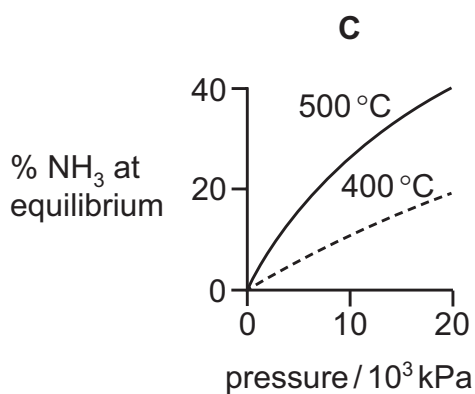
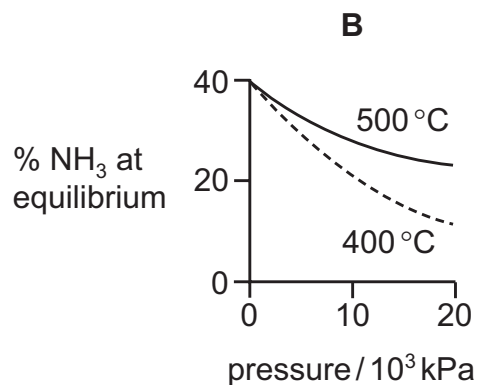
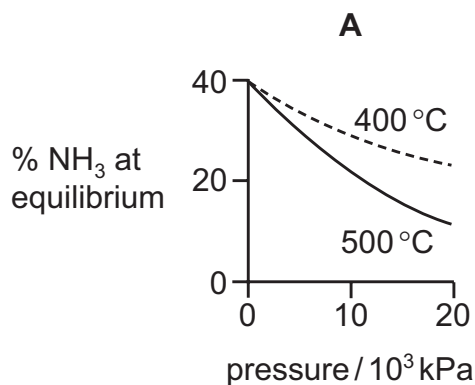
3.0 mol of ROH, 2.0 mol of ethanoic acid and 1.0 mol of water are mixed together. At equilibrium, 1.5 mol of CH_3COOR is present.

What is the value of the equilibrium constant, K_c , for this reaction?

- A** 0.20 **B** 0.25 **C** 2.00 **D** 5.00

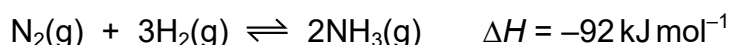
- 14** Graphs can be drawn to show the percentage of ammonia at equilibrium when nitrogen and hydrogen are mixed at different temperatures and pressures.

Which diagram correctly represents these two graphs?



127. Question | 9701 May-June 2024 P1 V2 Q13

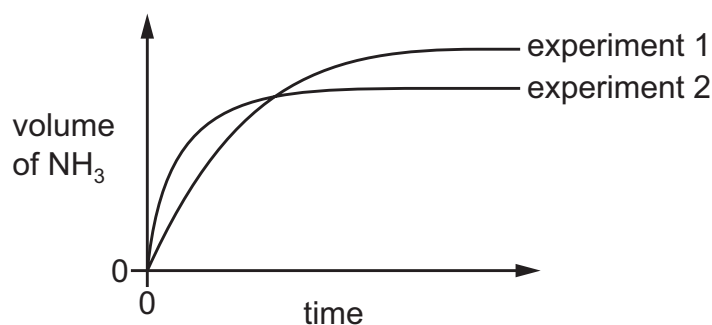
- 13** The volume of ammonia produced against time is measured in two experiments.



In experiment 1, 3 mol of $\text{H}_2(\text{g})$ and 1 mol of $\text{N}_2(\text{g})$ react together at 45°C and a pressure of 200 atm.

A graph showing the volume of ammonia produced against time is plotted.

Experiment 2 is then performed. Experiment 2 differs from experiment 1 in **one** condition only.



How does experiment 2 differ from experiment 1?

- A** An iron catalyst is present in experiment 2.
- B** 2 mol of helium gas is present in the reaction mixture in experiment 2.
- C** A pressure of 250 atm is used in experiment 2.
- D** A temperature of 600°C is used in experiment 2.

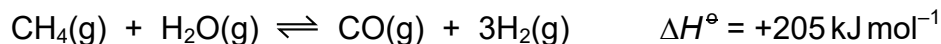
128. Question | 9701 May-June 2024 P1 V2 Q14

- 14** Which reaction has an equilibrium constant, K_p , that has no units?

- A** $\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$
- B** $3\text{H}_2(\text{g}) + \text{N}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$
- C** $2\text{NO}_2(\text{g}) \rightleftharpoons \text{N}_2\text{O}_4(\text{g})$
- D** $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \rightleftharpoons 2\text{SO}_3(\text{g})$

129. Question | 9701 May-June 2024 P1 V3 Q12

12 Hydrogen is produced industrially from methane as shown in the equation.

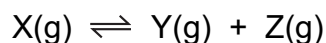


Which conditions give the highest yield of hydrogen at equilibrium?

	pressure	temperature
A	low	high
B	high	low
C	high	high
D	low	low

130. Question | 9701 May-June 2024 P1 V3 Q14

14 Gas X dissociates on heating to set up the following equilibrium.



A quantity of gas X is heated at constant pressure, p , at a certain temperature. The equilibrium partial pressure of gas X is found to be $\frac{1}{7}p$.

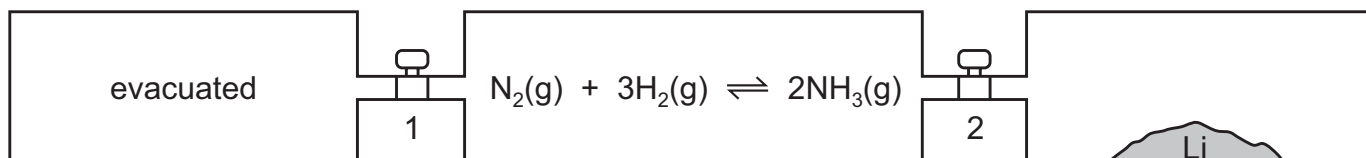
What is the equilibrium constant, K_p , at this temperature?

- A** $\frac{6}{7}p$ **B** $\frac{9}{7}p$ **C** $\frac{36}{7}p$ **D** $9p$

131. Question | 9701 Oct-Nov 2024 P1 V1 Q12

12 Lithium reacts with nitrogen at room temperature to form solid Li_3N .

Three vessels of equal volume are connected by taps 1 and 2 as shown.



At the start, taps 1 and 2 are closed, the left-hand vessel is evacuated, the middle vessel has the indicated reaction at equilibrium and the right-hand vessel contains lithium only.

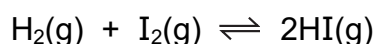
Which action would allow the equilibrium mixture to contain the **most** ammonia?

- A** Keep both taps 1 and 2 closed.
- B** Open both taps 1 and 2.
- C** Open tap 1 only.
- D** Open tap 2 only.

132. Question | 9701 Oct-Nov 2024 P1 V1 Q13

13 When 0.20 mol of hydrogen gas and 0.15 mol of iodine gas are heated at 723 K until equilibrium is established, the equilibrium mixture contains 0.26 mol of hydrogen iodide.

The equation for the reaction is as follows.

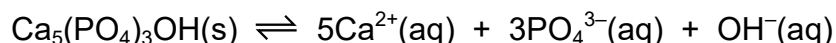


What is the correct expression for the equilibrium constant K_c ?

- A** $\frac{2 \times 0.26}{0.20 \times 0.15}$ **B** $\frac{(2 \times 0.26)^2}{0.20 \times 0.15}$ **C** $\frac{(0.26)^2}{0.07 \times 0.02}$ **D** $\frac{(0.26)^2}{0.13 \times 0.13}$

133. Question | 9701 Oct-Nov 2024 P1 V2 Q13

- 13** When some solid $\text{Ca}_5(\text{PO}_4)_3\text{OH}$ is added to a beaker of water, an equilibrium is set up.

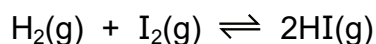


Which compound, when added to the equilibrium mixture, increases the amount of $\text{Ca}_5(\text{PO}_4)_3\text{OH}(\text{s})$ present?

- A** NH_3 **B** NH_4Cl **C** $\text{CH}_3\text{CO}_2\text{H}$ **D** NaCl

134. Question | 9701 Oct-Nov 2024 P1 V2 Q14

- 14** Gaseous hydrogen and gaseous iodine react to form gaseous hydrogen iodide.



In an experiment, 2.0 mol of hydrogen and 2.0 mol of iodine are placed in a sealed container of volume 1.0 dm^3 .

The K_c value for this reaction under the conditions used is 9.0.

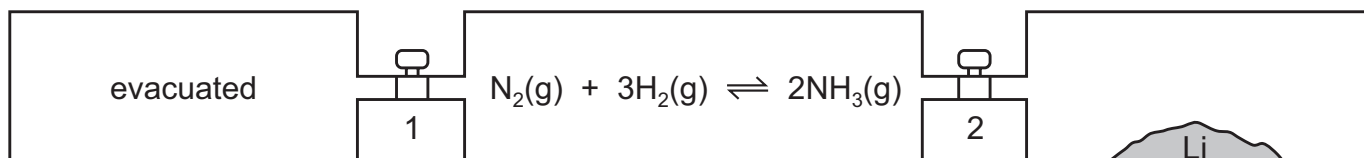
How many moles of hydrogen iodide are present at equilibrium?

- A** 0.57 mol **B** 1.2 mol **C** 1.5 mol **D** 2.4 mol

135. Question | 9701 Oct-Nov 2024 P1 V3 Q12

12 Lithium reacts with nitrogen at room temperature to form solid Li_3N .

Three vessels of equal volume are connected by taps 1 and 2 as shown.



At the start, taps 1 and 2 are closed, the left-hand vessel is evacuated, the middle vessel has the indicated reaction at equilibrium and the right-hand vessel contains lithium only.

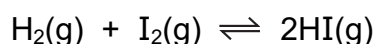
Which action would allow the equilibrium mixture to contain the **most** ammonia?

- A** Keep both taps 1 and 2 closed.
- B** Open both taps 1 and 2.
- C** Open tap 1 only.
- D** Open tap 2 only.

136. Question | 9701 Oct-Nov 2024 P1 V3 Q13

13 When 0.20 mol of hydrogen gas and 0.15 mol of iodine gas are heated at 723 K until equilibrium is established, the equilibrium mixture contains 0.26 mol of hydrogen iodide.

The equation for the reaction is as follows.



What is the correct expression for the equilibrium constant K_c ?

- A** $\frac{2 \times 0.26}{0.20 \times 0.15}$ **B** $\frac{(2 \times 0.26)^2}{0.20 \times 0.15}$ **C** $\frac{(0.26)^2}{0.07 \times 0.02}$ **D** $\frac{(0.26)^2}{0.13 \times 0.13}$

137. Question | 9701 Feb-March 2025 P1 V2 Q6

- 6** When an organic acid reacts with an alcohol, a reversible reaction takes place producing an ester and water.

0.40 mol of an organic acid and 0.30 mol of an alcohol are mixed and allowed to stand at 25 °C until equilibrium is reached.

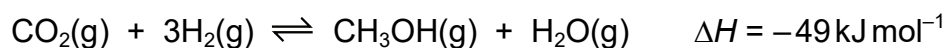
At equilibrium, 0.20 mol of ester is produced.

What is the value of the equilibrium constant, K_c , under the conditions used?

- A** 0.33 **B** 0.50 **C** 2.0 **D** 10

138. Question | 9701 Feb-March 2025 P1 V2 Q10

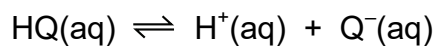
- 10** Methanol is manufactured by reacting carbon dioxide and hydrogen together.



What increases the equilibrium yield of methanol in this process?

- A** increasing the pressure
B adding an excess of steam
C adding a catalyst
D increasing the temperature

- 9 An aqueous solution X contains substance HQ which behaves as a weak acid.



The soluble salt NaQ is added to X.

What happens to the $[\text{H}^+(\text{aq})]$ and the pH in X?

	$[\text{H}^+(\text{aq})]$	pH
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

140. Question | 9701 May-June 2025 P1 V1 Q10

10 Dinitrogen tetroxide, N_2O_4 , decomposes reversibly.



An equilibrium mixture of N_2O_4 and NO_2 gases is placed in a closed container under standard conditions.

$$K_c = 1.15 \times 10^{-1} \text{ mol dm}^{-3}$$

The conditions are changed.

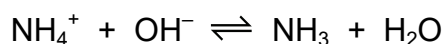
Under the new conditions, $K_c = 1.70 \times 10^3 \text{ mol dm}^{-3}$.

Which change in conditions occurs?

- A** The pressure increases.
- B** The pressure decreases.
- C** The temperature increases.
- D** The temperature decreases.

141. Question | 9701 May-June 2025 P1 V1 Q16

16 A reaction involving ammonium ions is shown.



Four statements about this reaction are listed.

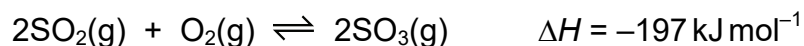
- 1 The ammonium ions are reduced.
- 2 In the reverse reaction, ammonia acts as a Brønsted–Lowry base.
- 3 The ammonium ion and the ammonia molecule have the same bond angle.
- 4 This reaction is **not** a redox reaction.

Which statements are correct?

- A** 1 and 2 **B** 1 and 3 **C** 2 and 4 **D** 3 and 4

142. Question | 9701 May-June 2025 P1 V2 Q4

- 4** The reaction between sulfur dioxide and oxygen has the equation shown.



1.0 mol of SO_2 and 1.0 mol of O_2 are placed in a closed container and heated to a constant temperature.

At this temperature, 0.8 mol of SO_3 are present in the equilibrium mixture.

Which statement is correct?

- A** The equilibrium partial pressure of SO_2 is greater than the equilibrium partial pressure of O_2 .
- B** K_p has units of mol dm^{-3} .
- C** At a lower temperature, the equilibrium amount of SO_3 is lower than 0.8 mol.
- D** The mole fraction of SO_3 is less than 0.8.

143. Question | 9701 May-June 2025 P1 V2 Q21

- 21** A reaction occurs when ammonium chloride is added to calcium hydroxide.

What is the role of the ammonium ions in this reaction?

- A** acid
- B** base
- C** oxidising agent
- D** reducing agent

144. Question | 9701 May-June 2025 P1 V3 Q5

- 5 The reversible reaction shown is in equilibrium at a temperature of 450 °C.



The table shows the equilibrium concentrations in the reaction mixture.

H_2	I_2	HI
1.02 mol dm^{-3}	0.02 mol dm^{-3}	0.98 mol dm^{-3}

The temperature of the reaction mixture is increased at constant volume.

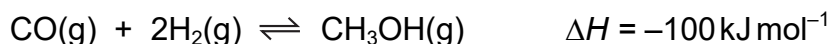
The concentration of one of the components **falls** to 0.80 mol dm^{-3} at equilibrium under these conditions.

What is the concentration of H_2 in the new equilibrium mixture?

- A 0.80 mol dm^{-3}
- B 0.93 mol dm^{-3}
- C 1.11 mol dm^{-3}
- D 1.20 mol dm^{-3}

145. Question | 9701 May-June 2025 P1 V4 Q7

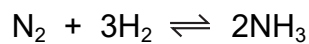
- 7 Methanol, CH_3OH , is made industrially from carbon monoxide and hydrogen in the equilibrium reaction shown.



Which statement about this equilibrium is correct?

- A K_p for the process is $\frac{p_{\text{CH}_3\text{OH}}}{p_{\text{CO}} \times p_{\text{H}_2}}$.
- B An increase in pressure increases the equilibrium yield of methanol.
- C An increase in temperature increases the equilibrium yield of methanol.
- D The addition of an effective catalyst increases the equilibrium yield of methanol.

- 15** A nitrogen–hydrogen mixture, initially in the mole ratio of 1 : 3, reaches equilibrium with ammonia when 50% of the nitrogen has reacted. The total final pressure is p .



What is the partial pressure of ammonia in the equilibrium mixture?

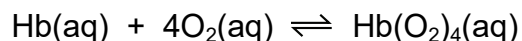
A $\frac{p}{6}$

B $\frac{p}{4}$

C $\frac{p}{3}$

D $\frac{p}{2}$

- 12** One molecule of haemoglobin, Hb, can bind with four molecules of oxygen according to the equation shown.



When the equilibrium concentration of O_2 is $7.6 \times 10^{-6} \text{ mol dm}^{-3}$, the equilibrium concentrations of Hb and $\text{Hb}(\text{O}_2)_4$ are equal.

What is the numerical value of K_c for this equilibrium?

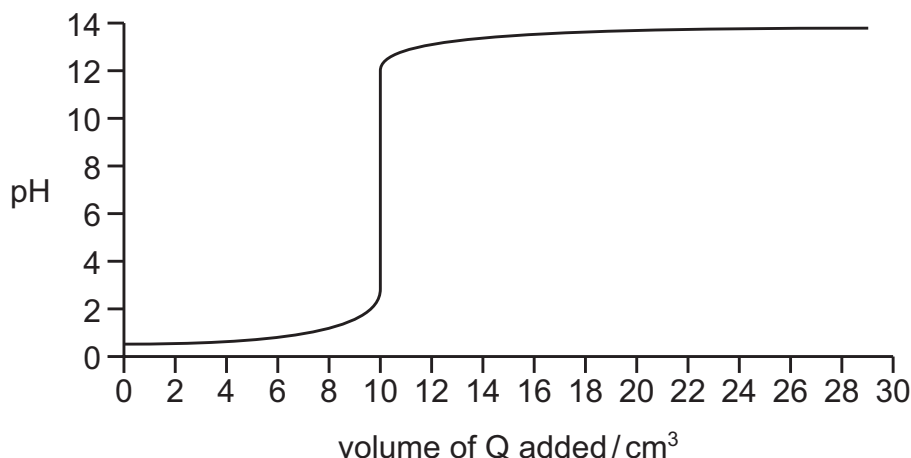
- A** 3.0×10^{20} **B** 1.3×10^5 **C** 7.6×10^{-6} **D** 3.3×10^{-21}

13 Aqueous acid P and aqueous alkali Q have the same concentration.

20 cm³ of P is added to a conical flask.

Q is slowly added to the flask and the volume of Q and the pH are recorded.

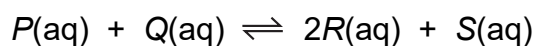
The pH titration curve is shown.



Which row gives the identity of P and Q?

	P	Q
A	HCl	NaOH
B	H ₂ SO ₄	NH ₃
C	HCl	Ba(OH) ₂
D	CH ₃ COOH	Sr(OH) ₂

12 An equilibrium can be represented by the equation shown.



In a certain mixture, of volume 1.0 dm³, the equilibrium concentration of Q is 10 mol dm⁻³.

What will be the new equilibrium concentration of Q if 5.0 mol of pure Q is completely dissolved in the mixture?

- A** 15 mol dm⁻³
- B** between 10 mol dm⁻³ and 15 mol dm⁻³
- C** 10 mol dm⁻³
- D** between 5.0 mol dm⁻³ and 10 mol dm⁻³

150. Question | 9701 Oct-Nov 2025 P1 V2 Q13

13 In the Contact process, sulfur dioxide and oxygen react to form sulfur trioxide.

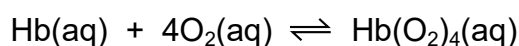
In the Haber process, nitrogen and hydrogen react to form ammonia.

Which statement about these processes is correct?

- A** K_p for the Haber process has no unit.
- B** In the Contact process, the value of K_p falls when pressure is increased at constant T.
- C** The Haber process uses a homogeneous catalyst.
- D** When V_2O_5 is used in the Contact process, the position of equilibrium is unchanged.

151. Question | 9701 Oct-Nov 2025 P1 V3 Q12

12 One molecule of haemoglobin, Hb, can bind with four molecules of oxygen according to the equation shown.



When the equilibrium concentration of O_2 is $7.6 \times 10^{-6} \text{ mol dm}^{-3}$, the equilibrium concentrations of Hb and $\text{Hb}(\text{O}_2)_4$ are equal.

What is the numerical value of K_c for this equilibrium?

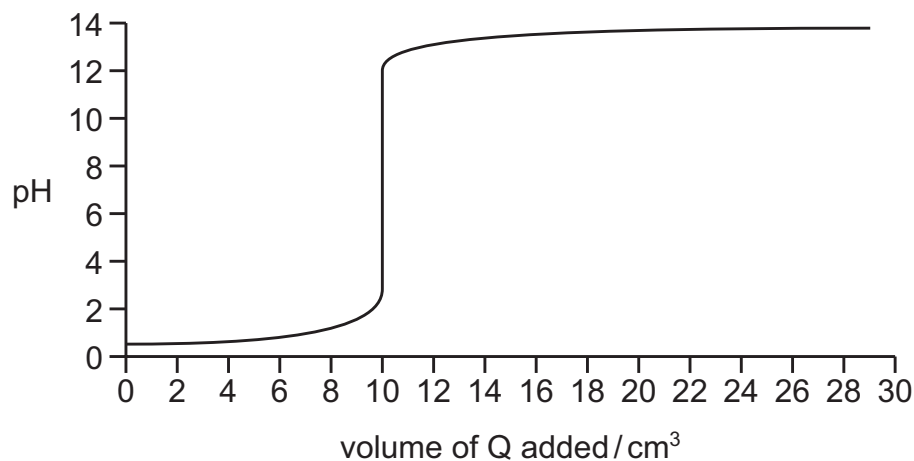
- A** 3.0×10^{20} **B** 1.3×10^5 **C** 7.6×10^{-6} **D** 3.3×10^{-21}

13 Aqueous acid P and aqueous alkali Q have the same concentration.

20 cm³ of P is added to a conical flask.

Q is slowly added to the flask and the volume of Q and the pH are recorded.

The pH titration curve is shown.



Which row gives the identity of P and Q?

	P	Q
A	HCl	NaOH
B	H ₂ SO ₄	NH ₃
C	HCl	Ba(OH) ₂
D	CH ₃ COOH	Sr(OH) ₂