CHEMISTRY

SmarterEd Maths & Sciences

HSC REVISION SERIES 2026

Welcome to the SmarterEd 2026 HSC Chemistry Revision Series.

Key features of this year's Revision Series include:

- ~17 hours of carefully selected HSC revision questions
- Targeted practice across the most important HSC question types
- Designed for students aiming for a Band 5-6 result
- Higher weighting towards historically difficult question types
- Topic and question weightings reflect historical HSC exam allocations
- Develop your own revision resource by ***carefully reviewing and annotating*** these worksheets throughout Term 3.

**Philosophy: Every question has earned its place. Historical HSC trends, common question types and past areas of student difficulty have all influenced the selection process.*

IMPORTANT

If you've already completed some of these questions during the year, **that's a good thing.**

Many of the highest-performing students credit repeated practice with challenging past HSC questions as a key ingredient in their HSC success. This revision series focuses on the highest-value question types, helping you build confidence and critically, *speed* through the exam.

HSC Final Study: M5 Equilibrium and Acid Reactions

Worksheet 3 of 4 | Estimated exam weighting of strand: 23.7%

Key Areas addressed by this worksheet:

Equilibrium Constant (6.6%)

- *Equilibrium Constant* has been examined in long response questions in 5 out of 7 years of the new syllabus (most recently in 2024) along with at least one multiple-choice question each year.
- Examiners love hammering calculation heavy questions involving *Keq* **(★)**. High mark allocations and low mean marks are typical when this content is tested. You have been warned!
- Revision questions in this topic area require students to determine the mols of a substance added to an equilibrium system (*2024 HSC 30*) and to explain the required changes in reaction conditions that would lead to certain equilibrium concentrations (*2021 HSC 31*).
- Other featured questions look at the formation of a *precipitate* **(★)** within the context of *Keq*. Close attention should be paid to *2019 HSC 17 MC* and *2021 HSC 19 MC* as they were poorly answered and we see the potential for the underlying concepts to be tested in longer response.
- Revision questions will typically provide the appropriate chemical equations, although be aware that some examples will require students to deduce chemical equations (see *2020 HSC 27*).
- The relationship between *Keq and pH* is a technical and calculation heavy concept that features in multiple longer response revision questions.

KEY: ★ Priority Revision – content or specific questions flagged by SM analysis as key revision.

"Effective study has no shortcut. It requires concentration, effort and good technique."

~ Kevin Bacon

CHEMISTRY 2026

HSC Revision Series

Smarter Ed

Module 5: Equilibrium and Acid Reactions

Equilibrium Constant

Exam Equivalent Time: 60 minutes *(based on allocation of 1.5 minutes per mark)*

Questions

1. CHEMISTRY, M5 2019 HSC 16 MC

At equilibrium, a 1.00 L vessel contains 0.0430 mol of H_2, 0.0620 mol of I_2, and 0.358 mole of HI. The system is represented by the following equation:

$$H_2\,(g) + I_2\,(g) \rightleftharpoons 2\,HI\,(g)$$

Which of the following is closest to the value of the equilibrium constant, K_{eq}, for this reaction?

A. 0.0208

B. 48.1

C. 134

D. 269

2. CHEMISTRY, M5 2022 HSC 8 MC

A system is described as follows.

$$2\,NaHCO_3\,(s) \rightleftharpoons Na_2CO_3\,(s) + CO_2\,(g) + H_2O\,(g)$$

What is the equilibrium expression for this system?

A. $K_{eq} = [CO_2]$

B. $K_{eq} = [CO_2]\,[H_2O]$

C. $K_{eq} = \dfrac{1}{[CO_2]\,[H_2O]}$

D. $K_{eq} = \dfrac{[Na_2CO_3]\,[CO_2]\,[H_2O]}{[NaHCO_3]^2}$

3. CHEMISTRY, M5 2023 HSC 7 MC

A mixture of 0.8 mol of $CO(g)$ and 0.8 mol of $H_2(g)$ was placed in a sealed 1.0 L container. The following reaction occurred.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

When equilibrium was established, the mixture contained 0.5 mol of $CO(g)$.

What amount of $H_2(g)$ was present at equilibrium?

A. 0.2 mol

B. 0.4 mol

C. 0.6 mol

D. 1.0 mol

4. CHEMISTRY, M5 2025 HSC 14 MC

The equation for the decomposition of hydrogen iodide is shown.

$$2\,HI(g) \rightleftharpoons I_2\,(g) + H_2\,(g) \qquad \Delta H = +\,52\ \text{kJ mol}^{-1}$$

The equilibrium formed during this reaction was investigated in two experiments carried out at different temperatures. The initial and equilibrium concentrations for both experiments are shown in the table, with only the K_{eq} for Experiment 1 shown.

	Initial concentrations (mol L^{-1})			*Equilibrium concentrations* (mol L^{-1})			*Equilibrium constant* (K_{eq})
	$[HI]$	$[H_2]$	$[I_2]$	$[HI]$	$[H_2]$	$[I_2]$	
Experiment 1	0.06	0.00	0.00	0.04	0.01	0.01	6×10^{-2}
Experiment 2	0.00	0.04	0.04	0.04	0.02	0.02	?

Which row in the table correctly compares features of the two experiments?

	K_{eq}	Temperature of *experiment*
A.	Lower in 1	Lower in 2
B.	Lower in 1	Higher in 2
C.	Higher in 1	Lower in 2
D.	Higher in 1	Higher in 2

5. CHEMISTRY, M5 2019 HSC 17 MC

A student makes a solution with a final volume of 200 mL by mixing 100 mL of 0.0500 mol L^{-1} barium nitrate solution with 100 mL of 0.100 mol L^{-1} sodium hydroxide solution.

Which row of the table correctly identifies if a precipitate will form under these conditions and the reason?

	Will a precipitate form?	*Reason*
A.	Yes	$Q > K_{sp}$
B.	Yes	$Q < K_{sp}$
C.	No	$Q > K_{sp}$
D.	No	$Q < K_{sp}$

6. CHEMISTRY, M5 2021 HSC 19 MC

A quantity of silver nitrate is added to 250.0 mL of 0.100 mol L^{-1} potassium sulfate at 298 K in order to produce a precipitate. Silver nitrate has a molar mass of 169.9 g mol^{-1}.

What mass of silver nitrate will cause precipitation to start?

A. 0.00510 g

B. 0.186 g

C. 0.465 g

D. 0.854 g

7. CHEMISTRY, M5 2024 HSC 15 MC

The thermal decomposition of lithium peroxide $(\mathrm{Li_2O_2})$ is given by the equation shown.

$$2\,\mathrm{Li_2O_2(s)} \rightleftharpoons 2\,\mathrm{Li_2\ O\,(s)} + \mathrm{O_2\,(g)}$$

Mixtures of $\mathrm{Li_2O_2}$, $\mathrm{Li_2O}$ and $\mathrm{O_2}$ were allowed to reach equilibrium in two identical, closed containers, P and Q, at the same temperature. The amount of $\mathrm{Li_2O_2\,(s)}$ in container P is double that in container Q. The amount of $\mathrm{Li_2O\,(s)}$ is the same in each container.

What is the ratio of $[\mathrm{O_2\,(g)}]$ in container P to $[\mathrm{O_2\,(g)}]$ in container Q?

A. $1:1$

B. $2:1$

C. $3:2$

D. $5:4$

8. CHEMISTRY, M5 2024 HSC 18 MC

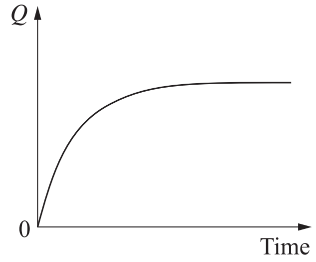
A reaction mixture, not at equilibrium, is composed of both $\mathrm{N_2O_4\,(g)}$ and $\mathrm{NO_2\,(g)}$ in a closed container. The reaction quotient for the system, Q, is given.

$$Q = \frac{[\mathrm{NO_2}]^2}{[\mathrm{N_2O_4}]}$$

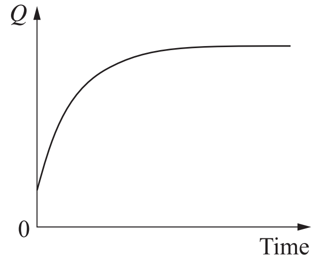
The rate of the forward reaction is initially greater than the rate of the reverse reaction.

Which diagram shows how Q changes over time for this mixture?

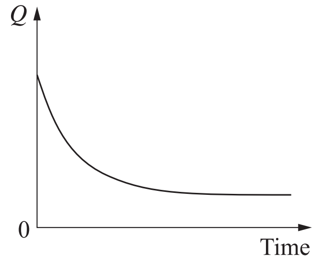
A.



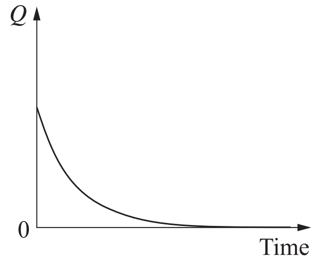
B.



C.



D.



9. CHEMISTRY, M5 EQ-Bank 11157 MC

0.20 moles of phosphorus pentachloride were heated to 200°C in a 2 L container in the presence of a vanadium catalyst according to the following reaction.

$$PCl_5\,(g) \rightleftharpoons PCl_3\,(g) + Cl_2\,(g)$$

At equilibrium, the mixture was found to contain 0.16 moles of chlorine.

Which of the following is the equilibrium constant for this reaction at this temperature?

A. 0.32

B. 0.64

C. 1.56

D. 3.13

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10. CHEMISTRY, M5 2019 HSC 31

The following reaction occurs in an aqueous solution.

$$HgCl_4{}^{2-}\,(aq) + Cu^{2+}\,(aq) \rightleftharpoons CuCl_4{}^{2-}\,(aq) + Hg^{2+} \qquad K_{eq} = 4.55 \times 10^{-11}$$

A solution containing a mixture of $HgCl_4{}^{2-}\,(aq)$ and $Cu^{2+}\,(aq)$ ions is prepared. The initial concentration of each ion is 0.100 mol L^{-1} and there are no other ions present.

Calculate the concentration of $Hg^{2+}\,(aq)$ ions once the system has reached equilibrium. *(4 marks)*

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11. CHEMISTRY, M5 2024 HSC 23

Consider the following equilibrium system.

$$[\mathrm{Co}\ (\mathrm{H_2O})_6]^{2+}\,(\mathrm{aq}) + 4\,\mathrm{Cl}^-\,(\mathrm{aq}) \rightleftharpoons [\mathrm{CoCl_4}]^{2-}\,(\mathrm{aq}) + 6\,\mathrm{H_2O}\,(\mathrm{l})$$

$[\mathrm{Co}(\mathrm{H_2O})_6]^{2+}\,(\mathrm{aq})$ is pink and $[\mathrm{CoCl_4}]^{2-}\,(\mathrm{aq})$ is blue. When a solution of these ions and chloride ions is heated, the mixture becomes more blue.

Relate the observed colour change to the change in K_{eq}. *(3 marks)*

12. CHEMISTRY, M5 EQ-Bank 12136

When a sample of solid silver chloride is added to a 1.00×10^{-2} mol L^{-1} sodium chloride solution, only some of the silver chloride dissolves.

Calculate the equilibrium concentration of silver ions in the resulting solution, given that the K_{sp} of silver chloride is 1.8×10^{-10}. *(3 marks)*

13. CHEMISTRY, M5 2020 HSC 35

In aqueous solution, iodide ions (I^-) react rapidly with iodine (I_2) to form triiodide ions I_3^-, making the equilibrium system shown in the chemical equation:

$$\mathrm{I}^-(aq) + \mathrm{I}_2(aq) \rightleftharpoons \mathrm{I}_3^-(aq)$$

The following relationships can be derived from the reaction mechanism:

$$[\mathrm{I}^-]_{eq} = 2[\mathrm{I}_2]_{eq}$$

$$[\mathrm{I}^-]_{initial} = 4[\mathrm{I}_2]_{eq} + 3[\mathrm{I}_3^-]_{eq}$$

where *'initial'* designates the initial concentration and *'eq'* designates the equilibrium concentration.

The absorbance of the solution in the UV-Vis spectrum is given by:

$$A = [\mathrm{I}_3^-] \times 2.76 \times 10^4$$

Determine the value of the equilibrium constant, given that $A = 0.745$ at equilibrium and $[\mathrm{I}^-]_{initial} = 7.00 \times 10^{-4}\ \mathrm{mol\,L^{-1}}$. ***(4 marks)***

14. CHEMISTRY, M5 2021 HSC 31

Ammonia is produced according to the following equilibrium equation.

$$\mathrm{N}_2(g) + 3\,\mathrm{H}_2(g) \rightleftharpoons 2\,\mathrm{NH}_3(g)$$

There are 4.50 moles of nitrogen gas, 1.00 mole of hydrogen gas and 5.80 moles of ammonia in a 10.0 L vessel. The system is at equilibrium at 298 K. The value of K_{eq} at this temperature is 748 .

How many moles of nitrogen gas need to be added to the vessel to increase the amount of ammonia by 0.050 moles? ***(4 marks)***

15. CHEMISTRY, M5 2024 HSC 30

An equilibrium mixture of hydrogen, carbon dioxide, water and carbon monoxide is in a closed, 1 L container at a fixed temperature as shown:

$$\mathrm{H_2\,(g) + CO_2\,(g) \rightleftharpoons H_2O\,(g) + CO\,(g)} \qquad K_{eq} = 1.600$$

The initial concentrations are
$[\mathrm{H_2}] = 1.000\ \mathrm{mol\ L^{-1}}$, $[\mathrm{CO_2}] = 0.500\ \mathrm{mol\ L^{-1}}$, $[\mathrm{H_2O}] = 0.400\ \mathrm{mol\ L^{-1}}$ and $[\mathrm{CO}] = 2.000\ \mathrm{mol\ L^{-1}}$.

An unknown amount of $\mathrm{CO\,(g)}$ was added to the same container, and the temperature was kept constant. After the new equilibrium had been established, the concentration of $\mathrm{H_2O\,(g)}$ was found to be 0.200 mol $\mathrm{L^{-1}}$.

Using this information, calculate the unknown amount (in mol) of $\mathrm{CO\,(g)}$ that was added to the container. *(4 marks)*

16. CHEMISTRY, M5 2020 HSC 27

A student makes up a solution of propan-2-amine in water with a concentration of 1.00 mol $\mathrm{L^{-1}}$.

a. Using structural formulae, complete the equation for the reaction of propan-2-amine with water. *(2 marks)*

$$\boxed{} + \mathrm{H_2O} \rightleftharpoons \boxed{} + \mathrm{OH^-}$$

b. The equilibrium constant for the reaction of propan-2-amine with water is 4.37×10^{-4}.

Calculate the concentration of hydroxide ions in this solution. *(3 marks)*

17. CHEMISTRY, M5 2024 HSC 39

Water and octan-1-ol do not mix. When an aqueous solution of bromoacetic acid $(\mathrm{BrCH_2COOH})$ is shaken with octan-1-ol, an equilibrium system is established between bromoacetic acid dissolved in the octan-1-ol and in the water.

$$\mathrm{BrCH_2COOH\,(aq)} \rightleftharpoons \mathrm{BrCH_2COOH}\,(octan\text{-}l\text{-}ol)$$

The equilibrium constant expression for this system is

$$K_{eq} = \frac{[\mathrm{BrCH_2COOH}\,(octan\text{-}l\text{-}ol)]}{[\mathrm{BrCH_2COOH}\,(aq)]}.$$

An aqueous solution of bromoacetic acid with an initial concentration of 0.1000 mol L $^{-1}$ is shaken with an equal volume of octan-1-ol. Bromoacetic acid does not dissociate in octan-1-ol but does dissociate in water, with $K_a = 1.29 \times 10^{-3}$. When the system has reached equilibrium, the $[\mathrm{H^+}]$ is 9.18×10^{-3} mol L^{-1}.

Calculate the equilibrium concentration of aqueous bromoacetic acid and hence, or otherwise, calculate the K_{eq} for the octan-1-ol and water system. ***(4 marks)***

Worked Solutions

1. CHEMISTRY, M5 2019 HSC 16 MC

$$K_{eq} = \frac{[\mathrm{HI}]^2}{[\mathrm{H_2}][\mathrm{I_2}]} = \frac{0.358^2}{(0.0430)(0.0620)} = 48.1$$

$\Rightarrow B$

2. CHEMISTRY, M5 2022 HSC 8 MC

- The concentrations of solids and pure liquids are omitted from the equilibrium expression because they have a constant concentration.
- Thus, the equilibrium expression is:

$$K_{eq} = [\mathrm{CO_2}][\mathrm{H_2O}]$$

$\Rightarrow B$

3. CHEMISTRY, M5 2023 HSC 7 MC

$$\mathrm{CO(g)} + 2\mathrm{H_2(g)} \rightleftharpoons \mathrm{CH_3OH(g)}$$

	CO (g)	2 H_2 (g)	CH_3OH
Initial	0.8	0.8	0
Change	$-x$	$-2x$	$+x$
Equilibrium	0.5	0.2	0.03

$x = 0.3$

$\Rightarrow A$

4. CHEMISTRY, M5 2025 HSC 14 MC

Mean mark 57%.

- The equilibrium constant for experiment two:

$$K_{eq}=\frac{[\mathrm{H_2}][\mathrm{I_2}]}{[\mathrm{HI}]^2}=\frac{0.02\times 0.02}{0.04^2}=0.25$$

- Therefore the K_{eq} for experiment 1 is lower than the K_{eq} for experiment 2.
- For an endothermic reaction (thinking of heat as a reactant), increasing the temperature of the reaction will shift the equilibrium to the products and increase K_{eq} which is what occured in experiment 2.
- Hence, the temperature of the experiment is higher in 2.

$\Rightarrow B$

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5. CHEMISTRY, M5 2019 HSC 17 MC

♦♦♦ Mean mark 36%.

$$\mathrm{Ba(OH)_2\,(s)}\rightleftharpoons \mathrm{Ba^{2+}\,(aq)}+2\,\mathrm{OH^-\,(aq)}$$

$$K_{sp}=2.55\times 10^{-4}$$

$$[\mathrm{Ba^{2+}}]=\frac{(0.05)(0.1)}{(0.2)}=0.025\,\mathrm{M}$$

$$[\mathrm{OH^-}]=\frac{(0.1)(0.1)}{(0.2)}=0.05\,\mathrm{M}$$

$$Q=[\mathrm{Ba^{2+}}][\mathrm{OH^-}]^2=(0.025)(0.05)^2=6.25\times 10^{-6}$$

Since $Q<K_{sp}$, no precipitate forms.

$\Rightarrow D$

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6. CHEMISTRY, M5 2021 HSC 19 MC

♦ Mean mark 45%.

The reaction when silver nitrate is added to potassium sulfate is:

$$2\mathrm{AgNO_3}(aq)+\mathrm{K_2SO_4}(aq)\ \rightarrow\ \mathrm{Ag_2SO_4}(s)+2\mathrm{KNO_3}(aq)$$

Since each $\mathrm{K_2SO_4}$ molecule has 1 sulfate ion

$$\left[\mathrm{SO_4^{2-}}\right]=\mathrm{K_2SO_4}=0.100\ \mathrm{mol\ L^{-1}}$$

$$\mathrm{Ag_2SO_4}(s)\leftrightharpoons 2\mathrm{Ag^+}(aq)+\mathrm{SO_4^{2-}}(aq)$$

$$\mathrm{K}_{sp}=\left[\mathrm{Ag^+}\right]^2\left[\mathrm{SO_4^{2-}}\right]$$

From the data sheet:

$$\mathrm{K}_{sp}=1.20\text{ x }10^{-5}$$

$$1.20\text{ x }10^{-5}=\left[\mathrm{Ag^+}\right]^2\times\left[\mathrm{SO_4^{2-}}\right]$$

$$1.20\text{ x }10^{-5}=\left[\mathrm{Ag^+}\right]^2\times[0.100]$$

$$\left[\mathrm{Ag^+}\right]=0.01095\ldots\ \mathrm{mol\ L^{-1}}$$

$$\left[\mathrm{Ag^+}\right]=[\mathrm{AgNO_3}]$$

$$\mathrm{n(AgNO_3)}=\mathrm{c}\times\mathrm{V}=0.01095\ldots\times 0.250=0.00273\ldots\ \mathrm{mol}$$

$$\mathrm{m(AgNO_3)}=\mathrm{n}\times\mathrm{MM}=0.00273\ldots\times 169.9=0.465\ \mathrm{g}$$

$\Rightarrow C$

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7. CHEMISTRY, M5 2024 HSC 15 MC

♦♦ Mean mark 39%.

- When calculating the K_{eq} of a system, substances in solid states are all given a value of 1.
- The equilibrium constant of the above reaction is $K_{eq}=[\mathrm{O_2\,(g)}]$.
- As both mixtures reached equilibrium, the K_{eq} values for each mixture is the same, hence the ratio of $[\mathrm{O_2\,(g)}]$ in each container is 1 : 1.

$\Rightarrow A$

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8. CHEMISTRY, M5 2024 HSC 18 MC

♦ Mean mark 43%.

- When calculating the reaction quotient of a chemical reaction, the formula is $\dfrac{products}{reactants}$.
- The equation for the reaction taking place is:

  $N_2O_4\,(g) \rightleftharpoons 2\,NO_2\,(g)$
- As the rate of the forward reaction is greater than the rate of the reverse reaction, $[NO_2]^2$ will increase and $[N_2O_4]$ will decrease.
- Hence the value for the reaction quotient, $\dfrac{[NO_2]^2}{[N_2O_4]}$, will increase.
- As it states both $N_2O_4\,(g)$ and $NO_2\,(g)$ are present in the intial system, the value for Q will not be zero.

$\Rightarrow B$

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9. CHEMISTRY, M5 EQ-Bank 11157 MC

$PCl_5\,(g) \rightleftharpoons PCl_3\,(g) + Cl_2\,(g)$

$$[PCl_5]_{\text{init}} = \frac{n}{V} = \frac{0.20}{2} = 0.10\,\text{mol L}^{-1}$$

	$[PCl_5]$	$[PCl_3]$	$[Cl_2]$
Initial	0.10	0	0
Change	-0.08	$+0.08$	$+0.08$
Equilibrium	0.02	0.08	0.08

$$K_{eq} = \frac{[PCl_3][Cl_2]}{[PCl_5]} = \frac{0.08^2}{0.02} = 0.32$$

$\Rightarrow A$

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10. CHEMISTRY, M5 2019 HSC 31

$$K_{eq} = \frac{[CuCl_4{}^{2-}][Hg^{2+}]}{[HgCl_4{}^{2-}][Cu^{2+}]}$$

	$[HgCl_4{}^{2-}]$	$[Cu^{2+}]$	$[CuCl_4{}^{2-}]$	$[Hg^{2+}]$
Initial	0.100	0.100	0	0
Change	$-x$	$-x$	$+x$	$+x$
Equilibrium	$0.100-x$	$0.100-x$	x	x

Since x is small $\Rightarrow 0.100 - x \approx 0.100$

$$4.55\times10^{-11} = \frac{x\times x}{(0.100-x)(0.100-x)}$$

$$4.55\times10^{-11} = \frac{x^2}{(0.100)^2}$$

$$x^2 = 4.55\times10^{-11}\times(0.100)^2$$

$$x = \sqrt{4.55\times10^{-11}\times(0.100)^2}$$

$$= 6.75\times10^{-7}\ \text{mol L}^{-1}$$

$$\therefore [Hg^{2+}] = 6.75\times10^{-7}\ \text{mol L}^{-1}$$

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11. CHEMISTRY, M5 2024 HSC 23

- When the solution is heated and the mixture becomes more blue, it suggests that the concentration of $[CoCl_4]^{2-}\,(aq)$ is increasing.
- The increase in temperature favoured the forward endothermic reaction and shifts the equilibrium position to the products.
- Therefore the concentrations of $[Co(H_2O)_6]^{2+}\,(aq)$ and $Cl^-\,(aq)$ will decrease.
- As $K_{eq} = \dfrac{[[CoCl_4]^{2-}]}{[[Co(H_2O)_6]^{2+}][Cl^-]^4}$, K_{eq} will increase.

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12. CHEMISTRY, M5 EQ-Bank 12136

$AgCl(s) \rightleftharpoons Ag^{+}(aq) + Cl^{-}(aq)$

	$[AgCl(s)]$	$[Ag^{+}(aq)]$	$[Cl^{-}(aq)]$
Initial		0	1.00×10^{-2}
Change		$+x$	$+x$
Equilibrium		x	$1.00 \times 10^{-2} + x$

Let $x = [Ag^{+}]$

$K_{sp} = [Ag^{+}][Cl^{-}]$

$K_{sp} = x(1.00 \times 10^{-2} + x) = 1.80 \times 10^{-10}$

Since x is small, $1.00 \times 10^{-2} + x \approx 1.00 \times 10^{-2}$

$$\begin{aligned} x(1.00 \times 10^{-2}) &= 1.80 \times 10^{-10} \\ x &= 1.80 \times 10^{-8} \\ \therefore [Ag^{+}] &= 1.80 \times 10^{-8}\ \text{mol L}^{-1} \end{aligned}$$

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13. CHEMISTRY, M5 2020 HSC 35

Mean mark 55%.

$$\begin{aligned} A &= [I_3^{-}]_{eq} \times 2.76 \times 10^{4} \\ 0.745 &= [I_3^{-}]_{eq} \times 2.76 \times 10^{4} \\ [I_3^{-}]_{eq} &= 2.70 \times 10^{-5}\ \text{mol L}^{-1} \end{aligned}$$

$$\begin{aligned} [I^{-}]_{initial} &= 4[I_2]_{eq} + 3[I_3^{-}]_{eq} \\ 7.00 \times 10^{-4} &= 4[I_2]_{eq} + (3 \times 2.70 \times 10^{-5}) \\ [I_2]_{eq} &= \frac{7.00 \times 10^{-4} - (3 \times 2.70 \times 10^{-5})}{4} \\ &= 1.55 \times 10^{-4}\ \text{mol L}^{-1} \end{aligned}$$

$$[I^{-}]_{eq} = 2[I_2]_{eq} = 2 \times (1.55 \times 10^{-4}) = 3.10 \times 10^{-4}\ \text{mol L}^{-1}$$

$$\begin{aligned} K_{eq} &= \frac{[I_3^{-}]_{eq}}{[I^{-}]_{eq} \times [I_2]_{eq}} \\ &= \frac{2.70 \times 10^{-5}}{3.10 \times 10^{-4} \times 1.55 \times 10^{-4}} \\ &= 564 \end{aligned}$$

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14. CHEMISTRY, M5 2021 HSC 31

	N_2	+ $3H_2$	$\leftrightharpoons$ $2NH_3$
Initial	$(4.5+x)$ moles	1.0 moles	5.8 moles
Change	-0.025 moles	-0.075 moles	$+0.05$ moles
Equilibrium	$(4.475+x)$ moles	0.925 moles	5.85 moles
Equilibrium concentration	$\dfrac{4.475+x}{10}$ mol L^{-1}	0.0925 mol L^{-1}	0.585 mol L^{-1}

♦ Mean mark 44%.

$$K_{eq}=\frac{[NH_3]^2}{[N_2][H_2]^3}$$

$$748=\frac{0.585^2}{\frac{4.475+x}{10}\times 0.0925^3}$$

$$748\times\frac{4.475+x}{10}\times 0.0925^3=0.585^2$$

$$\frac{4.475+x}{10}=\frac{0.585^2}{748\times 0.0925^3}$$

$$4.475+x=\frac{10\times 0.585^2}{748\times 0.0925^3}$$

$$x=\frac{10\times 0.585^2}{748\times 0.0925^3}-4.475$$

$$=1.3 \text{ moles (1 d.p.)}$$

$\therefore$ 1.3 moles of nitrogen must be added to the equilibrium mixture.

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15. CHEMISTRY, M5 2024 HSC 30

- $\mathrm{n_{intial}(CO\,(g))}=0.400$ and $\mathrm{n_{final}(CO\,(g))}=0.200.$
- Change in the number of moles in $\mathrm{CO\,(g)}=0.400-0.200=0.200$ mol in 1 L

♦ Mean mark 55%.

	$H_2\,(g)$	$CO_2\,(g)$	$H_2O\,(g)$	$CO_2\,(g)$
Initial	1	0.5	0.4	$2+x$
Change	$+0.2$	$+0.2$	-0.2	-0.2
Equilibrium	1.2	0.7	0.2	$1.8+x$

- Since all substances are present in a 1 L container, the concentrations of each substance is equal to the number of moles of that substance present at equilibrium

$$K_{eq}=\frac{[\mathrm{H_2O\,(g)}][\mathrm{CO\,(g)}]}{[\mathrm{H_2\,(g)}][\mathrm{CO_2\,(g)}]}$$

$$1.600=\frac{0.2\times(1.8+x)}{1.2\times 0.7}$$

$$1.8+x=1.6\times\frac{1.2\times 0.7}{0.2}$$

$$x=6.72-1.8$$

$$=4.92\text{ mol}$$

- 4.92 mol of $\mathrm{CO\,(g)}$ were added to the container.

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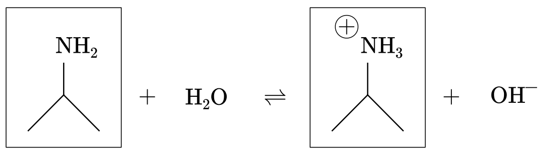
16. CHEMISTRY, M5 2020 HSC 27

a.



♦ Mean mark (a) 48%.

b.

Mean mark (b) 51%.

	$C_3H_7NH_2$	$C_3H_7NH_3$	OH^-
Initial	1.00	0	0
Change	$-x$	$+x$	$+x$
Equilibrium	$1.00-x$	x	x

$$K_b = \frac{[C_3H_7NH_3{}^+][OH^-]}{[C_3H_7NH_2]} = \frac{x^2}{(1.00-x)}$$

Assume $1.00 - x = 1.00$ because x is negligible:

$$4.37 \times 10^{-4} = \frac{x^2}{1.00}$$

$$x = \sqrt{4.37 \times 10^{-4}}$$

$$= 0.0209 \ \text{mol L}^{-1}$$

$$\Rightarrow [OH^-] = 0.0209 \ \text{mol L}^{-1}$$

17. CHEMISTRY, M5 2024 HSC 39

♦♦ Mean mark 27%.
COMMENT: Students who identified the acid conc in the organic solvent often succeeded in this question.

- The ionisation of bromoacetic acid in water is:

  $$\text{BrCH}_2\text{COOH (aq)} \rightleftharpoons \text{BrCH}_2\text{COO}^- \text{(aq)} + \text{H}^+ \text{(aq)}$$

- At equilibrium $[\text{BrCH}_2\text{COO}^- \text{(aq)}] = [\text{H}^+ \text{(aq)}] = 9.18 \times 10^{-3} \text{ mol L}^{-1}$ as the are formed in a 1 : 1.

$$K_a = \frac{[\text{H}^+][\text{BrCH}_2\text{COO}^-]}{[\text{BrCH}_2\text{COOH}]_{\text{eq}}}$$

$$[\text{BrCH}_2\text{COOH}]_{\text{eq}} = \frac{[\text{H}^+][\text{BrCH}_2\text{COO}^-]}{K_a}$$

$$= \frac{(9.18 \times 10^{-3})^2}{1.29 \times 10^{-3}}$$

$$= 0.06533 \text{ mol L}^{-1}$$

$$[\text{BrCH}_2\text{COOH}]_{\text{total}} = [\text{BrCH}_2\text{COOH (aq)}]_{\text{eq}} + [\text{BrCH}_2\text{COO}^- \text{(aq)}] + [\text{BrCH}_2\text{COOH(octan-1-ol)}]_{\text{eq}}$$

$$[\text{BrCH}_2\text{COOH(octan-1-ol)}]_{\text{eq}} = 0.1000 - 0.06533 - 9.18 \times 10^{-3}$$

$$= 0.02549 \text{ mol L}^{-1}$$

- Since the volume of the aqueous solution of bromoacetic acid and octane is the same, the concentration values between the water and octane solutions can be added/subtracted in one equation and mole calculations are not required.

$$K_{eq} = \frac{[\text{BrCH}_2\text{COOH(octan-1-ol)}]_{\text{eq}}}{[\text{BrCH}_2\text{COOH (aq)}]_{\text{eq}}} = \frac{0.02549}{0.06533} = 0.390 \text{ (3 sig. fig.)}$$