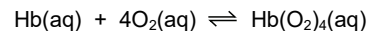


- 12** One molecule of haemoglobin, Hb, can bind with four molecules of oxygen according to the equation shown.

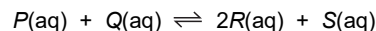


When the equilibrium concentration of O_2 is $7.6 \times 10^{-6} \text{ mol dm}^{-3}$, the equilibrium concentrations of Hb and $\text{Hb(O}_2)_4$ are equal.

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}

- 12** An equilibrium can be represented by the equation shown.



In a certain mixture, of volume 1.0 dm^3 , 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}

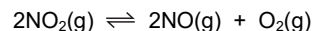
- 13** In the Contact process, sulfur dioxide and oxygen react to form sulfur trioxide.

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.

- 12** Nitrogen dioxide decomposes on heating according to the equation shown.



When 4 mol of nitrogen dioxide were put into a 1 dm^3 container and heated to a constant temperature, the equilibrium mixture contained 0.8 mol of oxygen.

What is the value of the equilibrium constant, K_c , at the temperature of the experiment?

- A** $\frac{0.8^2 \times 0.8}{4^2}$ **B** $\frac{1.6 \times 0.8}{2.4^2}$ **C** $\frac{1.6^2 \times 0.8}{4^2}$ **D** $\frac{1.6^2 \times 0.8}{2.4^2}$

- 13** One particle of X reacts with one particle of Y in a single-step reaction to produce two particles of Z.

This reaction is exothermic and reversible.



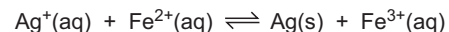
Three statements about the forward and reverse reactions are listed.

- 1 The activation energy of the forward reaction is equal to the activation energy of the reverse reaction.
- 2 At equilibrium, the frequency of collisions between one particle of X and one particle of Y is equal to the frequency of collisions between two particles of Z.
- 3 At equilibrium, the frequency of effective collisions between one particle of X and one particle of Y is equal to the frequency of effective collisions between two particles of Z.

Which statements are correct?

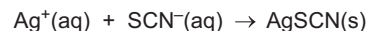
- A** 1 only **B** 2 and 3 **C** 2 only **D** 3 only

- 1 Aqueous silver ions, $\text{Ag}^+(\text{aq})$, react slowly with aqueous iron(II) ions, $\text{Fe}^{2+}(\text{aq})$. An equilibrium is established.

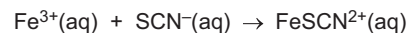


The concentration of $\text{Ag}^+(\text{aq})$ at equilibrium can be determined by titration with a standard solution of aqueous potassium thiocyanate, $\text{KSCN}(\text{aq})$.

During the titration, the remaining $\text{Ag}^+(\text{aq})$ ions react with $\text{SCN}^-(\text{aq})$ ions to form a precipitate of $\text{AgSCN}(\text{s})$.



When all $\text{Ag}^+(\text{aq})$ ions have been removed from solution, excess $\text{SCN}^-(\text{aq})$ ions react with $\text{Fe}^{3+}(\text{aq})$ to form a complex ion, $\text{FeSCN}^{2+}(\text{aq})$, which has a red colour.



The appearance of the red colour indicates the end-point.

A student carries out an experiment to determine the equilibrium constant, K_c .

$$K_c = \frac{[\text{Fe}^{3+}(\text{aq})]_{\text{eqm}}}{[\text{Fe}^{2+}(\text{aq})]_{\text{eqm}} [\text{Ag}^+(\text{aq})]_{\text{eqm}}}$$

The student makes 250.0 cm^3 of $0.0200\text{ mol dm}^{-3}$ $\text{KSCN}(\text{aq})$ to use in the titration.

- (a) Calculate the mass of solid potassium thiocyanate, $\text{KSCN}(\text{s})$, needed to make 250.0 cm^3 of $0.0200\text{ mol dm}^{-3}$ $\text{KSCN}(\text{aq})$.

mass of $\text{KSCN}(\text{s}) = \dots\dots\dots\text{g}$ [1]

- (b) Describe how the student should make 250.0 cm^3 of $0.0200\text{ mol dm}^{-3}$ $\text{KSCN}(\text{aq})$ starting from the mass of $\text{KSCN}(\text{s})$ calculated in (a) in a 50 cm^3 beaker.

Give the name and size of any key apparatus used.

Write your answer using a series of numbered steps.

.....
.....
.....
.....
.....
.....
..... [3]

- (c) The student uses the following method to determine K_c .

step 1 Add 25.0 cm^3 of 0.100 mol dm^{-3} aqueous silver nitrate, $\text{AgNO}_3(\text{aq})$, into a dry conical flask. Label this flask **A**.

step 2 Add 25.0 cm^3 of 0.100 mol dm^{-3} aqueous iron(II) sulfate, $\text{FeSO}_4(\text{aq})$, into flask **A**.

step 3 Seal flask **A**, using a bung.

step 4 Allow flask **A** to stand for twelve hours.

step 5 Transfer 10.0 cm^3 of the mixture from flask **A** into another conical flask, flask **B**, without disturbing the precipitate in flask **A**.

step 6 Titrate the sample in flask **B** with $0.0200\text{ mol dm}^{-3}$ aqueous potassium thiocyanate, $\text{KSCN}(\text{aq})$.

step 7 Repeat steps 5 and 6 until concordant values are obtained.

- (i) Suggest why flask **A** is sealed with a bung in step 3.

.....
..... [1]

- (ii) Suggest why flask **A** is left to stand for twelve hours in step 4.

.....
..... [1]

- (iii) Identify the precipitate in flask **A** in step 5.

- (d) The student's results are shown in Table 1.1

Table 1.1

	rough titration	titration 1	titration 2	titration 3
final burette reading / cm ³	22.50	21.75	31.65	32.20
initial burette reading / cm ³	0.00	0.00	9.75	10.20
titre / cm ³	22.50	21.75	21.90	22.00

- (i) State if concordant titres have been achieved.

Explain your answer.

.....
..... [1]

- (ii) Calculate the percentage error in the titre volume in titration 2.

Show your working.

percentage error = [1]

- (iii) The student repeats the experiment using KSCN(aq) at a **higher** concentration. The student obtains **smaller** titres.

Suggest **one** reason why a larger titre is better than a smaller titre.

..... [1]

- (e) Another student calculates a mean titre of 21.85 cm³. Use this value to complete the following calculation.

- (i) Calculate [Ag⁺(aq)] in the equilibrium mixture in flask **A**.

$$[\text{Ag}^+(\text{aq})]_{\text{eqm}} = \dots\dots\dots \text{mol dm}^{-3} \quad [1]$$

- (ii) Calculate [Fe³⁺(aq)] in the equilibrium mixture in flask **A**.

$$[\text{Fe}^{3+}(\text{aq})]_{\text{eqm}} = \dots\dots\dots \text{mol dm}^{-3} \quad [1]$$

- (iii) The formula for the equilibrium constant, K_c , is shown.

$$K_c = \frac{[\text{Fe}^{3+}(\text{aq})]_{\text{eqm}}}{[\text{Fe}^{2+}(\text{aq})]_{\text{eqm}} [\text{Ag}^+(\text{aq})]_{\text{eqm}}}$$

Determine the value of K_c .

Give the units of K_c .

$$K_c = \dots\dots\dots$$

units [2]

- (f) Several other students perform the same experiment at different temperatures. The K_c values that they obtain are used to produce the graph in Fig. 1.1.

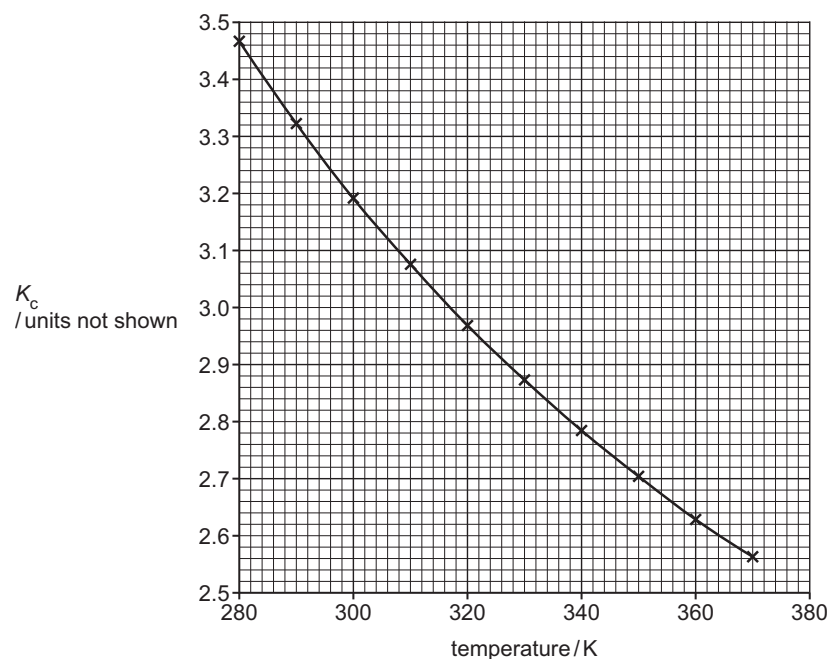


Fig. 1.1

- (i) One student suggests that K_c is directly proportional to temperature.
State and explain if the results displayed in Fig. 1.1 support this suggestion.

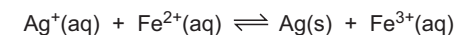
.....
..... [1]

- (ii) Another student suggests that the data represented in the graph in Fig. 1.1 is reliable.

Explain how the graph supports this suggestion.

.....
.....
..... [1]

- (iii) Use the data displayed in Fig. 1.1 to state if the forward reaction is exothermic or endothermic.



Explain your answer.

forward reaction

explanation

.....

.....

[1]

[Total: 17]