Group 2

Question Paper 5

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Group 2
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 5

Time Allowed: **51 minutes**

Score: **/42**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 **(a)** Barium ions are poisonous. Patients with digestive tract problems are sometimes given an X-ray after they have swallowed a 'barium meal', consisting of a suspension of $BaSO_4$ in water. The $[Ba^{2+}(aq)]$ in a saturated solution of $BaSO_4$ is too low to cause problems of toxicity.

(i) Write an expression for the solubility product, K_{sp}, for $BaSO_4$, including its units.

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(ii) The numerical value of K_{sp} is 1.30×10^{-10}. Calculate $[Ba^{2+}(aq)]$ in a saturated solution of $BaSO_4$.

.....

.....

(iii) The numerical value of K_{sp} for $BaCO_3$ (5×10^{-10}) is not significantly higher than that for $BaSO_4$, but barium carbonate is **very** poisonous if ingested. Suggest a reason why this might be so.

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.....

[3]

(b) A useful commercial source of magnesium is sea water, where $[Mg^{2+}(aq)]$ is $0.054\,mol\,dm^{-3}$. The magnesium is precipitated from solution by adding calcium hydroxide.

$$Mg^{2+}(aq) + Ca(OH)_2(s) \longrightarrow Ca^{2+}(aq) + Mg(OH)_2(s)$$

(i) Write an expression for the K_{sp} of $Mg(OH)_2$, including its units.

.....

(ii) The numerical value for K_{sp} is 2.00×10^{-11}. Calculate $[Mg^{2+}(aq)]$ in a saturated solution of $Mg(OH)_2$.

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.....

(iii) Hence calculate the maximum percentage of the original magnesium in the seawater that this method can extract.

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.....

[5]

(c) The magnesium ions in seawater are mainly associated with chloride ions.

(i) Use the following $\Delta H_f^{\ominus}$ values to calculate a value for the $\Delta H^{\ominus}$ of the following reaction.

$$MgCl_2(s) \longrightarrow Mg^{2+}(aq) + 2Cl^-(aq)$$

species	$\Delta H_f^{\ominus}$ /kJ mol^{-1}
$MgCl_2$ (s)	–641
Mg^{2+}(aq)	–467
Cl^- (aq)	–167

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(ii) Use your answer to explain why $MgCl_2$ is very soluble in water.

.....

[2]

(d) All the chlorides of Group II elements are soluble in water. The same is not true of their sulphates. These become less soluble as the group is descended.

Explain qualitatively the variation in solubility of the sulphates of the elements in Group II down the Group from magnesium to barium.

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.....[2]

[Total : 12]

2 With the prospect that fossil fuels will become increasingly scarce in the future, many compounds are being considered for use in internal combustion engines. One of these is DME or dimethyl ether, CH_3OCH_3. DME is a gas which can be synthesised from methanol. Methanol can be obtained from biomass, such as plant waste from agriculture.

(a) Define, with the aid of an equation which includes state symbols, the standard enthalpy change of combustion, $\Delta H_c^{\ominus}$, for DME at 298 K.

equation .....

definition .....

.....

..... [3]

(b) DME may be synthesised from methanol. Relevant enthalpy changes of formation, $\Delta H_f^{\ominus}$ for this reaction are given in the table below.

compound	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$CH_3OH(l)$	–239
$CH_3OCH_3(g)$	–184
$H_2O(l)$	–286

Use these values to calculate $\Delta H_{reaction}^{\ominus}$ for the synthesis of DME, using the following equation. Include a sign in your answer.

$$2CH_3OH(l) \rightarrow CH_3OCH_3(g) + H_2O(l)$$

$\Delta H_{reaction}^{\ominus}$ = ... kJ mol^{-1}
[3]

(c) DME and ethanol are isomers with the molecular formula C_2H_6O.

(i) Draw the displayed formula of DME and of ethanol.

DME	ethanol

(ii) What type of isomerism do DME and ethanol show?

.....

[2]

(d) DME is a gas at room temperature while ethanol is a liquid.

(i) Which intermolecular force exists between ethanol molecules, which causes ethanol to be a liquid at room temperature?

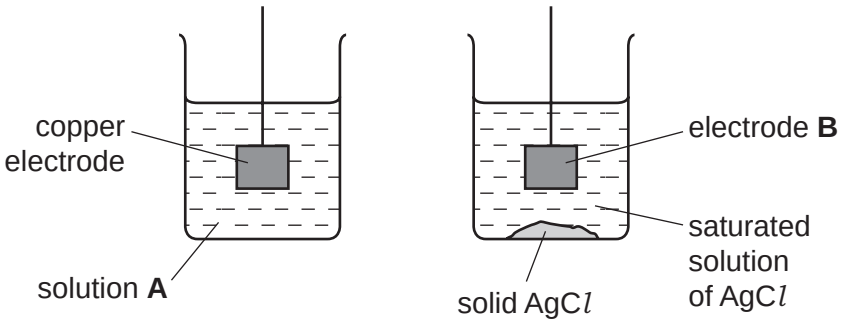
.....

(ii) Draw a diagram that clearly shows this intermolecular force.
Your diagram should show any lone pairs or dipoles present that you consider to be important. You should represent at least two molecules in your diagram.

[4]

[Total: 12]

3 **(a)** The diagram below shows an incomplete experimental set-up needed to measure the E_{cell} of a cell composed of the standard Cu^{2+}/Cu electrode and an Ag^{+}/Ag electrode.



(i) State the chemical composition of

solution **A**, ...

electrode **B**. .....

(ii) Complete the diagram to show the whole experimental set-up.

[4]

(b) The above cell is not under standard conditions, because the $[Ag^{+}]$ in a saturated solution of AgC*l* is much less than 1.0 mol dm^{-3}. The $E_{electrode}$ is related to $[Ag^{+}]$ by the following equation.

equation 1 $\qquad E_{electrode} = E^{\ominus}_{electrode} + 0.06 \log[Ag^{+}]$

(i) Use the *Data Booklet* to calculate the $E^{\ominus}_{cell}$ if the cell was operating under standard conditions.

$E^{\ominus}_{cell}$ = ... V

In the above experiment, the E_{cell} was measured at +0.17V.

(ii) Calculate the value of $E_{electrode}$ for the Ag^{+}/Ag electrode in this experiment.

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(iii) Use equation 1 to calculate $[Ag^{+}]$ in the saturated solution.

$[Ag^{+}]$ = ... mol dm^{-3}

[3]

(c) Write an expression for K_{sp} of silver sulfate, Ag_2SO_4, including units.

K_{sp} = ... units .....

Using a similar experimental set-up to that illustrated opposite, it is found that $[Ag^+]$ in a saturated solution of Ag_2SO_4 is 1.6×10^{-2} mol dm^{-3}.

(ii) Calculate the value of K_{sp} of silver sulfate.

K_{sp} = ...
[3]

(d) Describe how the colours of the silver halides, and their relative solubilities in $NH_3(aq)$, can be used to distinguish between solutions of the halide ions Cl^-, Br^- and I^-.

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..... [4]

(e) Describe and explain the trend in the solubilities of the sulfates of the elements in Group II.

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..... [4]

[Total: 18]