Student Number……

Hornsby Girls' High School

2019
Year 12 Task 1
Processing and Analysing Data

Chemistry

General Instructions

- Reading time – 5 minutes
- Working time – 60 minutes
- Write using blue or black pen
- Draw diagrams using a pencil
- NESA-approved calculators must be used
- A data sheet, formulae sheets and Periodic Table are provided at the back of this paper and may be detached for your convenience
- Write your student number at the top of this page and multiple-choice answer sheet
- Attempt all questions
- The multiple-choice answer sheet may be detached for convenience.
- Marks are as indicated in brackets

Total marks – 50 marks

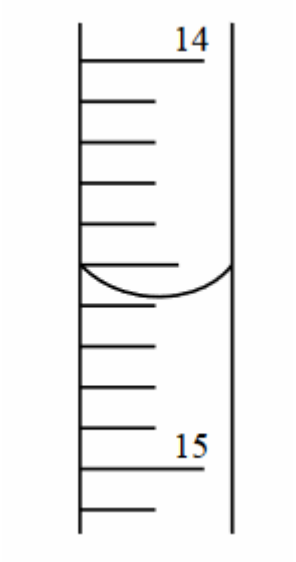
- Section I - Multiple Choice 10 marks
- Section II – Written Response 40 marks

Section I

Attempt Questions 1–10
Allow about 10 minutes for this part

Use the multiple-choice answer sheet for Questions 1 – 10

1 The diagram below shows a section of a 50.00 mL burette containing a colourless solution.



The reading indicated on the burette is closest to which of the following values?

(A) 14.50

(B) 14.58

(C) 15.42

(D) 15.50

2 Which equation would represent the greatest decrease in entropy?

(A) $2O_{3(g)} \rightarrow 3O_{2(g)}$

(B) $C_{(s)} + O_{2(g)} \rightarrow CO_{2(g)}$

(C) $2H_2O_{2(s)} \rightarrow 2H_2O_{(l)} + O_{2(g)}$

(D) $HCl_{(g)} + NH_{3(g)} \rightarrow NH_4Cl_{(s)}$

3 Given the following information

$$Cl_{2(g)} \rightleftharpoons 2Cl_{(g)}; \qquad K = 1.13 \times 10^{-6} \text{ at } 1100^{o}C$$

What would be the numerical value of the equilibrium constant for the reaction

$$2Cl_{(g)} \rightleftharpoons Cl_{2(g)}$$

at the same temperature?

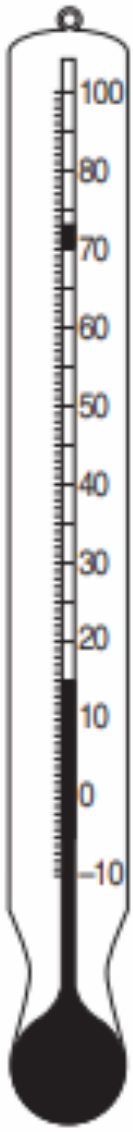
(A) 4.42×10^{5}

(B) 8.85×10^{5}

(C) 1.13×10^{6}

(D) 2.26×10^6

4 An investigation was carried out to measure how quickly substances dissolve at different temperatures. The thermometer used for the investigation was faulty because a small part of the liquid column had become detached and stuck near the 70°C mark. In all other respects the thermometer was responding normally to changes in temperature. The diagram shows the thermometer when the actual room temperature was 18°C.



Which statement is correct about the investigation carried out using this thermometer?

(A) The investigation is valid because the thermometer is responding normally to temperature changes.

(B) The investigation is reliable because consistent results can be obtained when the experiment is repeated.

(C) The investigation is invalid because correct temperature readings can only be deduced if the temperature is 73°C.

(D) The investigation is unreliable unless the person recording the measurements adds 3°C to each of the temperatures observed.

5 The four equations below represent different equilibrium systems.

Equation 1: $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$ $\Delta H = -180$ kJ mol^{-1}

Equation 2: $CO_{(g)} + H_2O_{(g)} \rightleftharpoons CO_{2(g)} + H_{2(g)}$ $\Delta H = -46$ kJ mol^{-1}

Equation 3: $PCl_{5(g)} \rightleftharpoons PCl_{3(g)} + Cl_{2(g)}$ $\Delta H = 93$ kJ mol^{-1}

Equation 4: $CH_{4(g)} + H_2O_{(g)} \rightleftharpoons CO_{(g)} + 3H_{2(g)}$ $\Delta H = 205$ kJ mol^{-1}

After equilibrium was established in each system, the temperature was decreased, and the pressure was increased.

In which equilibrium system would both changes result in an increase in yield?

(A) Equation 1

(B) Equation 2

(C) Equation 3

(D) Equation 4

6 Which of the following reactions at equilibrium is closest to completion?

(A) $2O_{3(g)} \rightleftharpoons 3O_{2(g)}$ $K_{eq} = 2.0 \times 10^{57}$

(B) $2SO_{2(g)} + O_{2(g)} \rightleftharpoons 2SO_{3(g)}$ $K_{eq} = 4.3$

(C) $N_{2(g)} + 3H_{2(g)} \rightleftharpoons 2NH_{3(g)}$ $K_{eq} = 9.0$

(D) $NH_{3(aq)} + H_2O_{(l)} \rightleftharpoons NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$ $K_{eq} = 1.8 \times 10^{-5}$

7 Which expression below represents K_{eq} for the following reaction?

$$Fe_3O_{4(s)} + 4H_{2(g)} \rightleftharpoons 3Fe_{(s)} + 4H_2O_{(g)}$$

A $\dfrac{[H_2O(g)]^4}{[H_2(g)]^4}$

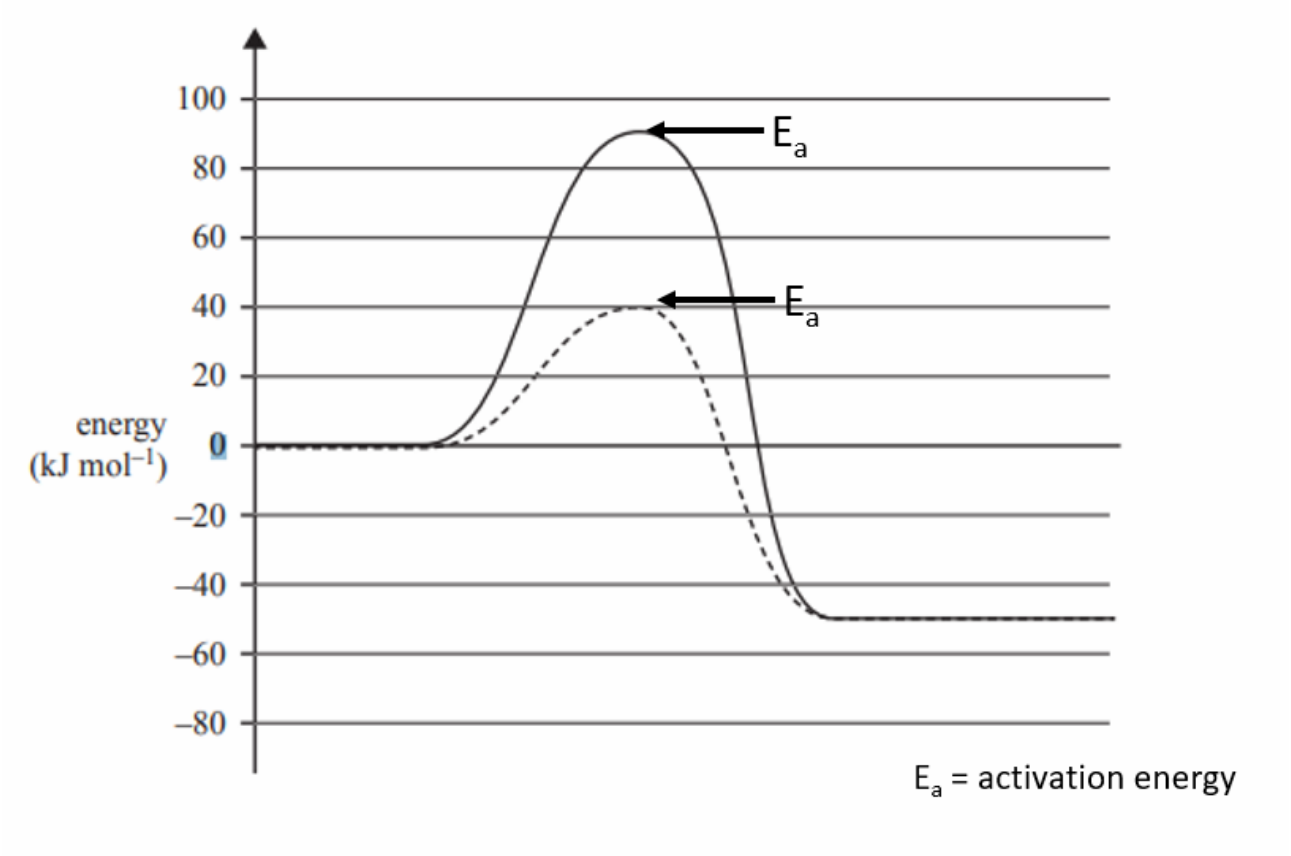
B $\dfrac{[H_2(g)]^4}{[H_2O(g)]^4}$

C $\dfrac{[Fe(s)]^3[H_2O(g)]^4}{[Fe_3O_4(s)][H_2(g)]^4}$

D $\dfrac{[Fe_3O_4(s)][H_2(g)]^4}{[Fe(s)]^3[H_2O(g)]^4}$

8

The energy profile diagram below represents a particular reaction. One graph represents the uncatalysed reaction and the other graph represents the catalysed reaction

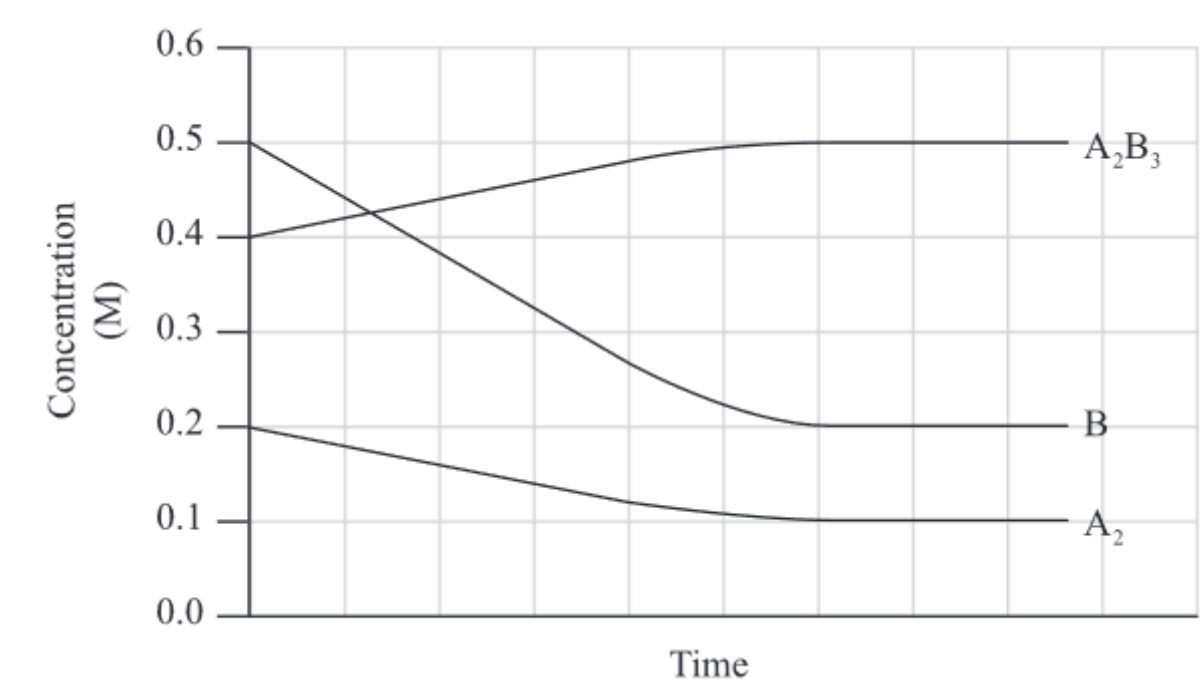


Which of the following best matches the energy profile diagram?

	E_a uncatalysed reaction (kJ mol^{-1})	ΔH catalysed reaction (kJ mol^{-1})
A.	40	–140
B.	90	–140
C.	40	–50
D.	90	–50

9 Consider the following gaseous reaction: $A_2 + 3B \rightleftharpoons A_2B_3$

Quantities of all three chemicals are placed in a 5.0 L vessel at 1000 K and the system is allowed to come to equilibrium. The graph below indicates the changes in concentration with time.



The equilibrium constant for the reaction at 1000K is:

A $\dfrac{0.5}{0.1\times3(0.5)}$ **C** $\dfrac{0.5}{0.1\times(0.2)^3}$

B $\dfrac{0.1\times3(0.2)}{0.5}$ **D** $\dfrac{0.1\times(0.2)^3}{0.5}$

10 Calculate the molar solubility of AgI in 0.050M $NaI_{(aq)}$ at 25°C.

(A) 1.7×10^{-15}

(B) 8.5×10^{-15}

(C) 1.7×10^{-17}

(D) 2.9×10^{-17}

11

Section II

Attempt Questions 11-15

Allow about 50 minutes for this part

Answer questions in the space provided. These spaces provide guidance for the expected length of response. Show all relevant working in questions involving calculations.

Question 11 (6 marks)

In solution, pale yellow-coloured $Fe^{3+}_{(aq)}$ and colourless $SCN^{-}_{(aq)}$ form an equilibrium with $FeSCN^{2+}_{(aq)}$. $FeSCN^{2+}_{(aq)}$ is red in colour.

$$Fe^{3+}_{(aq)} + SCN^{-}_{(aq)} \rightleftharpoons FeSCN^{2+}_{(aq)} \qquad \Delta H < 0$$

(pale yellow-colour) (red colour)

(a) Annie investigates this reaction using separate samples of an equilibrium mixture in which significant quantities of Fe^{3+}, SCN^{-} and $FeSCN^{2+}$ are present. In each case changes are made as indicated in the table below.

Complete the table by placing ticks in the appropriate boxes to indicate the effect of each change on

(4)

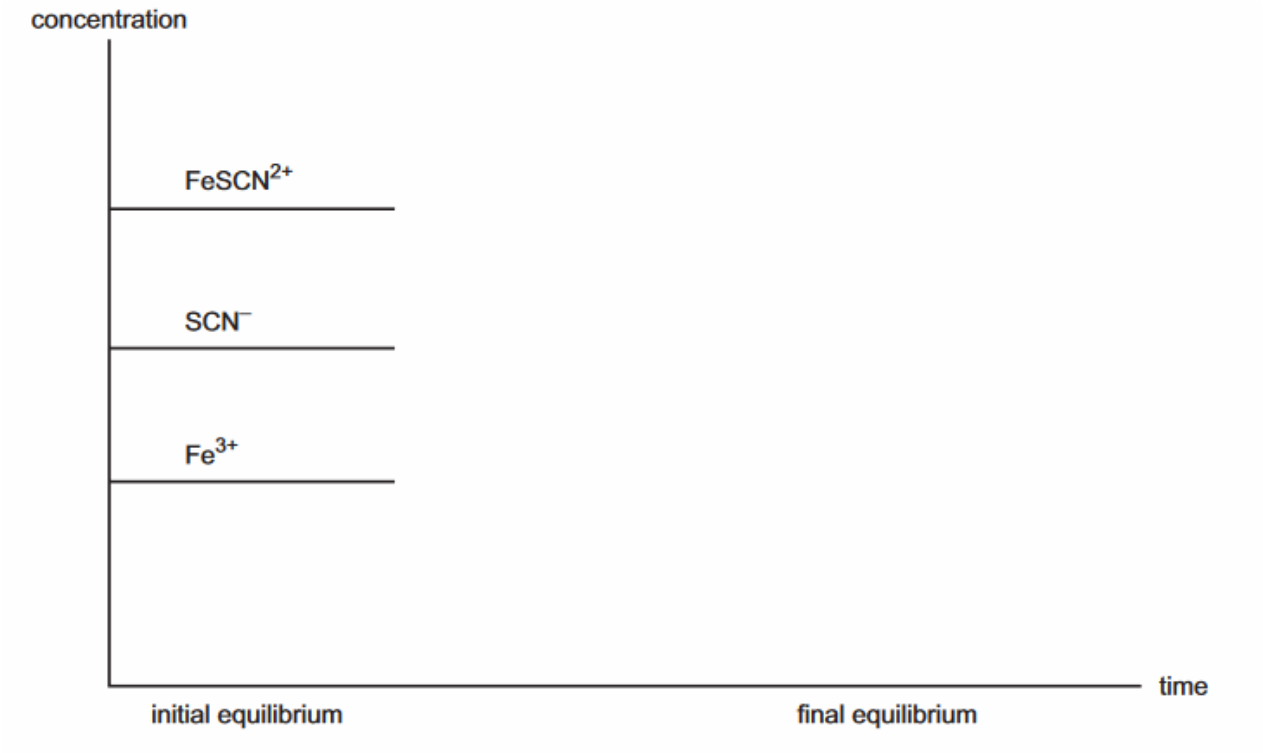
I. the intensity of the red colour of the solution

II. the concentration of $Fe^{3+}_{(aq)}$, once the new equilibrium has been established

Change in equilibrium	**I. Colour at new equilibrium compared with initial equilibrium**		**II. $[Fe^{3+}]$ at equilibrium compared with initial equilibrium**	
	less red	more red	decreased	increased
Sample 1: 1 drop of concentrated solution of $Ag^{+}_{(aq)}$ is added, which forms a AgSCN precipitate				
Sample 2: Addition of a large volume of water				

(b) The reaction is exothermic. The graph below represents the initial concentrations of the ions at equilibrium. Sketch the changes that would be expected to occur to these concentrations if the temperature of the equilibrium mixture was increased to a new, constant value.

(2)



Question 12 (3 marks)

(a) Calculate ΔS° in (J K^{-1} mol^{-1}) at 298 K for the following reaction.

(2)

$CH_{4(g)} + N_{2(g)} \rightleftharpoons HCN_{(g)} + NH_{3(g)}$; $\Delta H° = 164.1$ kJ mol^{-1}; $\Delta G° = 159.1$ kJ mol^{-1} at 298 K

(b) Assuming ΔH° and ΔS° are constant with respect to temperature, under what conditions will a chemical reaction be spontaneous at all temperatures?

(1)

Question 13 (13 marks)

To determine the value of the solubility product for a sparingly soluble salt $Ca(OH)_2$. Alex used the following method:

1. Take a bottle of saturated solution containing about 2 g of powdered calcium hydroxide in 100 mL of distilled water. This bottle has been shaken well and set aside for more than a day.
2. Filter the contents of the bottle by collecting filtrate in a dry beaker.
3. Rinse and fill the burette with standardised hydrochloric acid (0.100 M).
4. Rinse the pipette with the calcium hydroxide solution and transfer 25.00 mL to a conical flask.
5. Add 2-3 drops of phenolphthalein (pH indicator) to the flask and titrate the solution with HCl until the pink colour just disappears. Record the amount of HCl used in the burette.

   The results are record below.

		Trial			
		1	**2**	**3**	**4**
Burette readings of 0.100M HCl (mL)	**Final**	10.84	21.55	33.64	43.84
	Initial	0.38	10.84	21.55	33.64
Volume (mL)		10.46	10.71		10.20

(a) Calculate the missing value in the table above.

(1)

(b) Calculate the average volume of the results.

(1)

(c) Calculate the concentration of Ca^{2+} and OH^- ions in the solution

(3)

(d)

Calculate the experimental value of K_{sp} for $Ca(OH)_2$

(2)

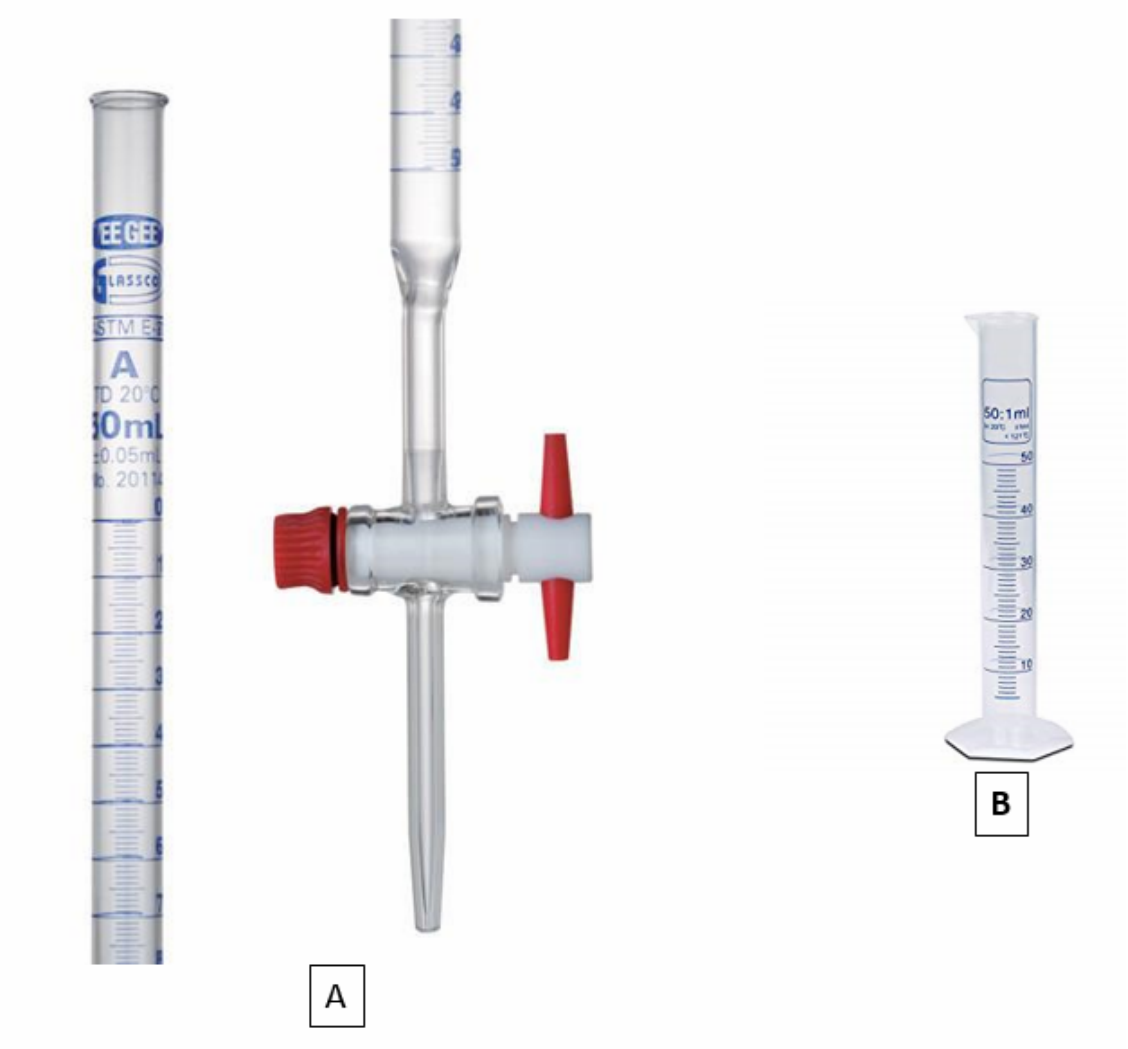
(e) Jasmine made several actions during this analytical procedure listed below. For each action, Identify and explain the likely effect on the calculated value of K_{sp}.

(4)

Action	**Effect**
The conical flask had been previously washed with water but not dried.	
Not all of the $Ca(OH)_2$ solid was filtered off the solution	

(f)

The glassware in A and B below can be used to hold different volumes of liquid.



Identify the glassware in diagram A and describe ONE reason why A is used over B in step 3.

(2)

Question 14 (6 marks)

The table below shows the molar solubilities of several ionic compounds in pure water, in 1.0 M sodium sulfate solution and in 1.0 M barium nitrate solution.

Compound	Solubility (mol L^{-1})		
	In pure H_2O	In 1.0 M Na_2SO_4	In 1.0 M $Ba(NO_3)_2$
$SrSO_4$	5.66×10^{-4}	3.20×10^{-7}	5.66×10^{-4}
$PbSO_4$	1.34×10^{-4}	1.30×10^{-8}	1.34×10^{-4}
$BaSO_4$	3.87×10^{-5}	1.50×10^{-9}	1.50×10^{-9}
PbF_2	2.15×10^{-3}	2.15×10^{-3}	2.15×10^{-3}
BaF_2	1.82×10^{-2}	1.82×10^{-2}	2.45×10^{-3}
$BaCO_3$	4.00×10^{-4}	4.00×10^{-4}	1.60×10^{-9}
$SrCO_3$	2.65×10^{-5}	2.65×10^{-5}	2.65×10^{-5}

(a) Identify the ionic compound with the highest solubility in pure water.

(1)

(b) Calculate the solubility (g/100mL of pure water) of $PbSO_4$ in pure H_2O.

(2)

(c) Write a conclusion regarding solubility patterns that may be inferred from this data. Clearly justify your response.

(3)

Question 15 (12 marks)

Anna prepared a series of standard solutions of iron thiocyanate ($FeSCN^{2+}$) using the following reaction below and then placed each one in a cuvette.

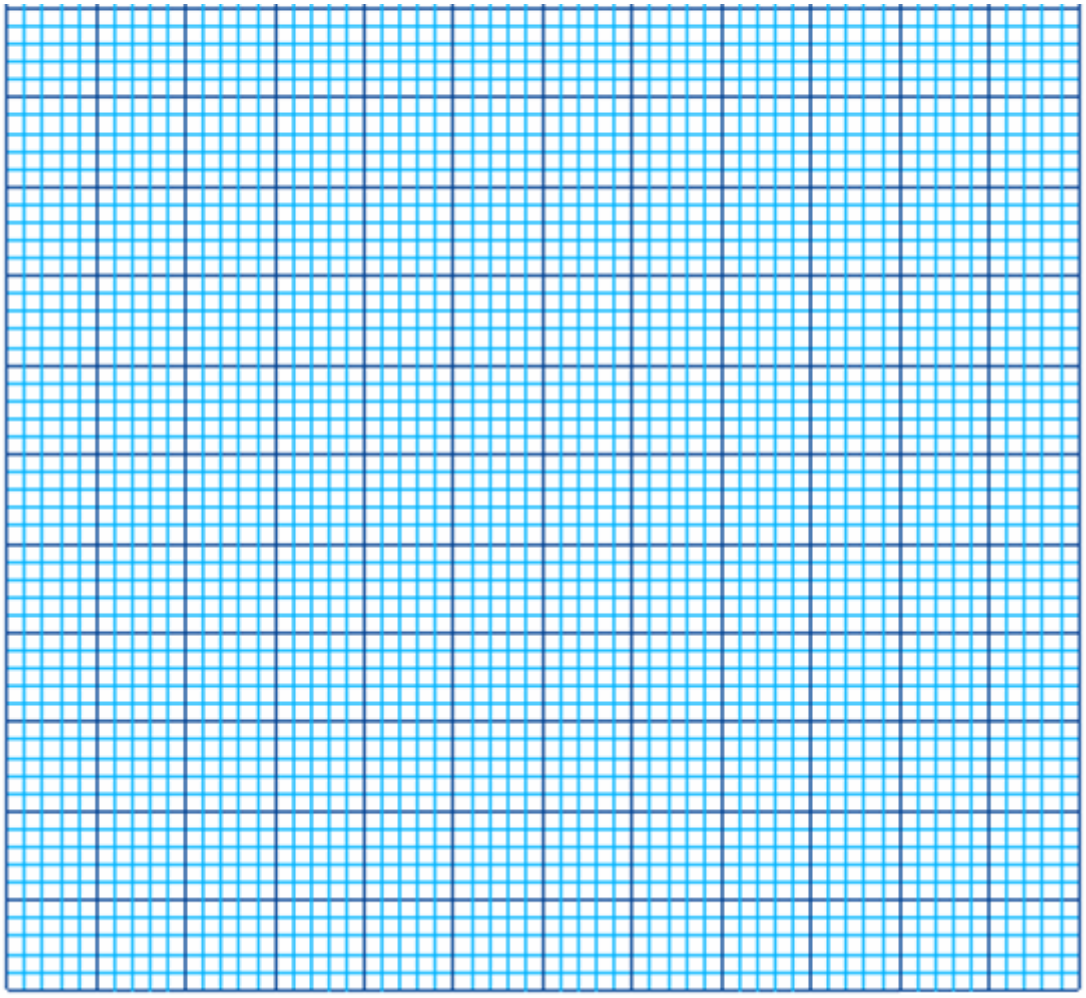
$$Fe^{3+}_{(aq)} + SCN^{-}_{(aq)} \rightleftharpoons FeSCN^{2+}_{(aq)}$$

The percent transmittance was measured at 505 nm in a colourimeter. The results were then converted to absorbance as shown below.

Solution	Blank	Standard 1	Standard 2	Standard 3	Standard 4
$[FeSCN^{2+}]$ (mol L^{-1})	0.00	0.15	0.30	0.45	0.60
Absorbance	0.02	0.24	0.50	0.72	0.99

(a) Plot a graph of absorbance vs concentration (mol L^{-1}) and draw a line of best fit.

(4)



The equation of the line for the graph plotted above is: **y = 1.64x - 0.002**

(b) An unknown sample of iron thiocyanate ($FeSCN^{2+}$) gave an absorbance reading of 0.35. Calculate the concentration iron thiocyanate ($FeSCN^{2+}$) at equilibrium using the equation of the line.

(2)

(c) The equilibrium constant K_{eq} for the reaction is 1.34. Calculate the initial concentration of $[Fe^{3+}]$ and $[SCN^{-}]$ if they are equal in concentration to begin with.

(4)

(d) Discuss the validity of this experiment in determining the value of equilibrium constant based on the results from the standard solutions.

(2)