Write-on

Chemistry A
Unit H432

Practice Paper 1A

Name	

Time allowed
2 hours 15 minutes

Information
- The total marks available for this paper is 100. The number of marks available for each question is shown in brackets.
- Answer all questions and show all working

You will need:
An OCR A Chemistry data sheet

You may use:
- A scientific or graphical calculator
- A pencil for graphs and drawings
- A ruler

Question	Mark
MCQs	
16	
17	
18	
19	
20	
21	
Total	

Paper 1A

SECTION A

You should aim to finish this section within 20 minutes.

1 Calculate the relative atomic mass of sulfur based on the following isotopic distribution.

Number of neutrons in isotope	Isotopic abundance (%)
16	94.90
17	0.80
18	4.30

A 32.09

B 32.10

C 16.09

D 16.10

Your answer ☐

2 Identify which of the following can act as a reducing agent for $Cu^{2+}_{(aq)}$.

A OH^-

B NH_3

C H_2O_2

D I^-

Your answer ☐

3 Which of the following gives the correct ionic equation for the reaction of nitric acid with sodium carbonate?

A $Na^+_{(aq)} + CO_3^{2-}{}_{(aq)} + 2H^+_{(aq)} + NO_3^-{}_{(aq)} \rightarrow Na^+_{(aq)} + CO_{2(g)} + H_2O_{(l)} + NO_3^-{}_{(aq)}$

B $Na^+_{(aq)} + CO_3^{2-}{}_{(aq)} + 2H^+_{(aq)} + NO_3^-{}_{(aq)} \rightarrow Na^+_{(aq)} + CO_{2(g)} + H_{2(g)} + NO_3^-{}_{(aq)}$

C $CO_3^{2-}{}_{(aq)} + 2H^+_{(aq)} \rightarrow NaNO_{3(aq)} + CO_{2(g)} + H_2O_{(l)}$

D $CO_3^{2-}{}_{(aq)} + 2H^+_{(aq)} \rightarrow CO_{2(g)} + H_2O_{(l)}$

Your answer ☐

4 If 5.0 g of magnesium chloride is obtained from the reaction of 5.0 g of magnesium with hydrochloric acid, what is the percentage yield?

A 25 %

B 50 %

C 20 %

D 41 %

Your answer ☐

5 Define 'enthalpy of formation'.

A Enthalpy change when a compound is formed from one mole of its elements at 273 K and 100 kPa, with all reactants and products in their standard states

B Enthalpy change when one mole of a compound is formed from one mole of its elements at 273 K and 100 kPa, with all reactants and products in their standard states

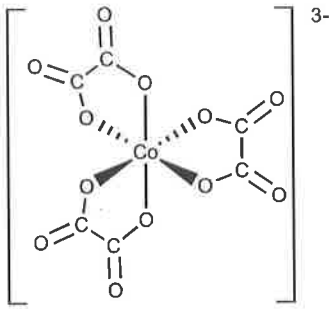
C Enthalpy change when one mole of a compound is formed from its elements at 298 K and 100 kPa, with all reactants and products in their standard states

D Enthalpy change when one mole of a compound is formed from one mole of its elements at 298 K and 100 kPa, with all reactants and products in their standard states

Your answer ☐

6 Which of the complexes below **cannot** exhibit stereoisomerism?

A



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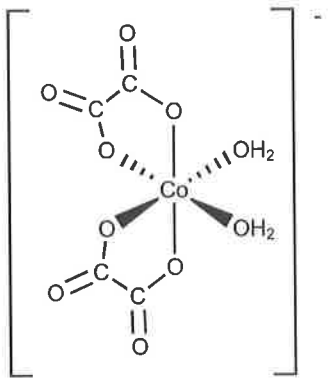

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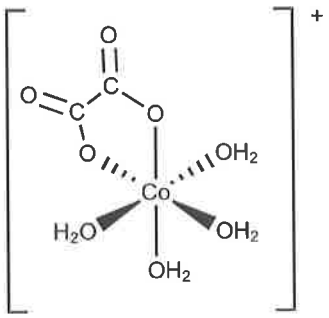

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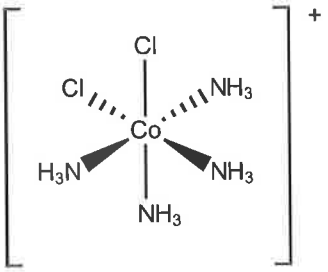


Your answer ☐

7 When green copper carbonate is heated using a Bunsen burner, it decomposes to form black CuO. Identify which of the following **cannot** be used to determine an initial rate of reaction.

A Conduct the reaction on a balance. Time taken for the mass of starting material to decrease by a certain amount.

B Attach the reaction to a gas syringe. Time taken for a certain volume of gas to be produced (allowing for expansion of air).

C Observe the reaction carefully, holding a timer. Time taken for the green copper carbonate to go completely black.

D Connect the reaction flask to a U-tube filled with lime water. Time taken for lime water to go milky.

Your answer ☐

8 Identify which of the following has the most negative value:

A The second electron affinity of oxygen

B The first electron affinity of oxygen

C The first ionisation energy of oxygen

D The fifth ionisation energy of oxygen

Your answer ☐

9 The indicator bromocresol green exists in two forms:

$$C_{21}H_{13}Br_4O_5S^- \rightleftharpoons C_{21}H_{12}Br_4O_5S^{2-} + H^+$$

Yellow Blue

Which of the following statements explains the effect of adding acid?

A Adding acid increases the concentration of H^+, causing the position of equilibrium to shift right and making the solution more yellow.

B Adding acid increases the concentration of H^+, causing the position of equilibrium to shift left and making the solution more yellow.

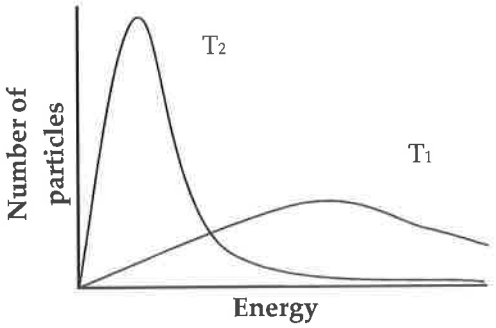
C Adding acid decreases the concentration of H^+, causing the position of equilibrium to shift right and making the solution more blue.

D Adding acid increases the concentration of H^+, causing the position of equilibrium to shift right and making the solution more blue.

Your answer ☐

10 Which of the following shows the Maxwell–Boltzmann distribution of molecular energies for a given sample of gas at two temperatures where $T_1 > T_2$?

A



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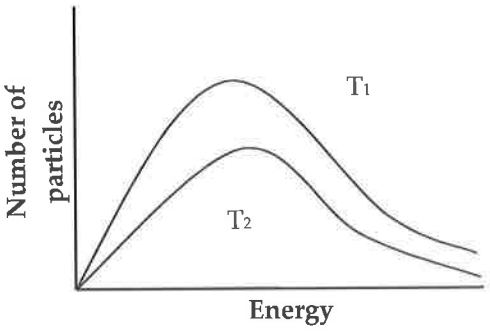

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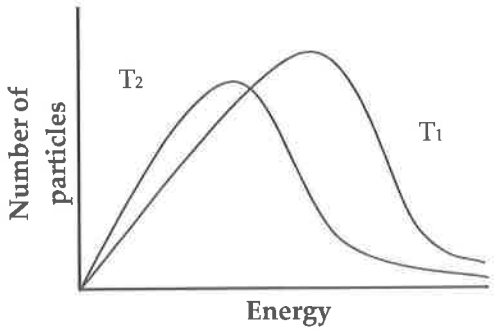

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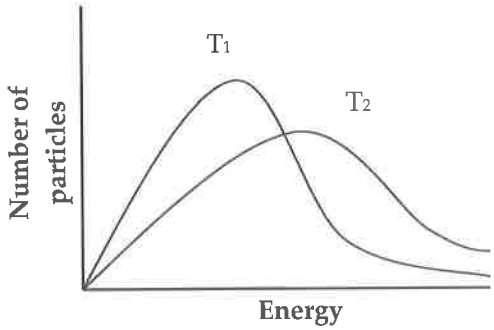

Your answer ☐

11 Which of the following statements is true of a fuel cell?

A Oxygen is always required, hydrogen or alternatives may be used.

B Hydrogen is always required, oxygen or alternatives may be used.

C Oxygen and hydrogen are both always used in a fuel cell.

D Hydrogen and oxygen are common in fuel cells, but both are optional.

Your answer ☐

12 Iodine atoms combine to form iodine molecules in the gas phase in a second-order reaction.

If 1.00×10^{-5} atoms of iodine gives a rate of production of iodine molecules of 0.78 mol dm^{-3} s^{-1}, calculate the value of the rate constant.

A 7.8×10^{4}

B 7.8×10^{-4}

C 7.8×10^{9}

D 7.8×10^{-9}

Your answer ☐

13 Ammonium nitrate is a common fertiliser that dissolves in water. Which of the following is true of the solution?

1. If it is warmed gently, it will turn damp litmus blue.
2. It can conduct electricity.
3. It will form a white precipitate if aqueous silver ions are added to it.

A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 3

Your answer ☐

14 Which of the following statements about ionisation energy are true?

1. Oxygen has a higher first ionisation energy than nitrogen because it has an extra proton.
2. Boron has a higher first ionisation energy than beryllium because it has a higher nuclear charge.

A Statement 1 only

B Statement 2 only

C Statements 1 and 2

D Neither statement 1 nor statement 2

Your answer ☐

15 Which of the following show a conjugate acid–base pair?

1. Acid: NH_3 Base: NH_2^-
2. Base: PO_4^{3-} Acid: HPO_4^{2-}
3. Acid: ArH^+ Base: Ar

A Only 1

B Only 1 and 2

C Only 2 and 3

D 1, 2 and 3

Your answer ☐

SECTION B

16 A student carried out a series of experiments using the following electrochemical data as a basis:

① $Ag^{+}_{(aq)} + e^{-} \rightleftharpoons Ag_{(s)}$ $E^{\ominus} = +0.80$ V

② $Al^{3+}_{(aq)} + 3e^{-} \rightleftharpoons Al_{(s)}$ $E^{\ominus} = -1.66$ V

③ $Fe^{3+}_{(aq)} + e^{-} \rightleftharpoons Fe^{2+}_{(aq)}$ $E^{\ominus} = +0.77$ V

a) From the list above, identify the best reducing agent, explaining your answer.

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(2)

b) Calculate the standard cell potential if equations ① and ② were combined.

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(1)

c) Draw a labelled diagram of a circuit that can be used to experimentally determine the emf generated when half cells ② and ③ are combined, identifying any key conditions.

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d) Explain why the combination of half cells ① and ③ is unlikely to give a reaction even though it may be feasible according to electrochemical values.

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(1)

e)* Determination of the concentration of Fe^{2+} in a sample may be achieved by titration of the sample with acidified potassium permanganate solution.

Outline how this experiment can be used for determination of the concentration of Fe^{2+} in a 25.00 cm^3 sample of factory waste water.

You should include:

- equations for all reactions taking place
- equipment needed
- details of how to carry out the titration

You do not need to include details of calculations or repeats.

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(6)

QUESTION TOTAL: 14 MARKS

17 Barium hydroxide, $Ba(OH)_2$, is an alkali formed from the dissolution of barium metal in water. Calcium forms calcium hydroxide in the same way.

a) Write a balanced equation for the reaction of barium with water.

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[2]

b) A chemist wanted to accurately compare the pH of a solution formed from the same number of moles of barium and calcium.

i) Describe, experimentally, how the chemist would go about making this comparison.

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[3]

ii) Predict, qualitatively, the outcome of the comparison. Justify your prediction.

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[1]

c) i) A solution of $Ba(OH)_2$ was found to have a pH of 10.94 at 298 K. Using the value of $K_w = 1.00 \times 10^{-14}$, calculate the $[OH^-]$ that this contains.

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[2]

ii) 50.00 cm^3 of this solution was neutralised by 25.00 cm^3 of nitrous acid, HNO_2, a monobasic weak acid with a K_a of 4.51×10^{-4}. Calculate the concentration of the nitrous acid.

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[4]

QUESTION TOTAL: 12 MARKS

18 Sulfonyl chloride, SO_2Cl_2, is used in industry to produce pesticides. It can be made by reacting sulfur dioxide and chlorine according to the equation:

$$SO_{2(g)} + Cl_{2(g)} \rightleftharpoons SO_2Cl_{2(g)}$$

a) Explain why, in terms of atom economy, this would be considered a sustainable process.

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[2]

b) Draw and name the shape of the molecule SO_2Cl_2 and predict the bond angle.

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[3]

c) i) Use the following bond energy data to predict the enthalpy change for this reaction.

Bond	Average bond enthalpy (kJ mol^{-1})
S=O	523
S–Cl	253
Cl–Cl	242

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ii) Suggest why this value does not fit with values calculated from the experiment.

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[1]

d) i) 0.400 moles of $SO_{2(g)}$ were added to an equal number of moles of $Cl_{2(g)}$ at a pressure of 2.00 kPa and temperature of 303 K in a closed system. At equilibrium 0.0240 moles of $SO_{2(g)}$ remained. Calculate the value and unit of K_P.

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ii) The equation can be written to form SO_2Cl_2 as a liquid. How does this affect the equation for K_P?

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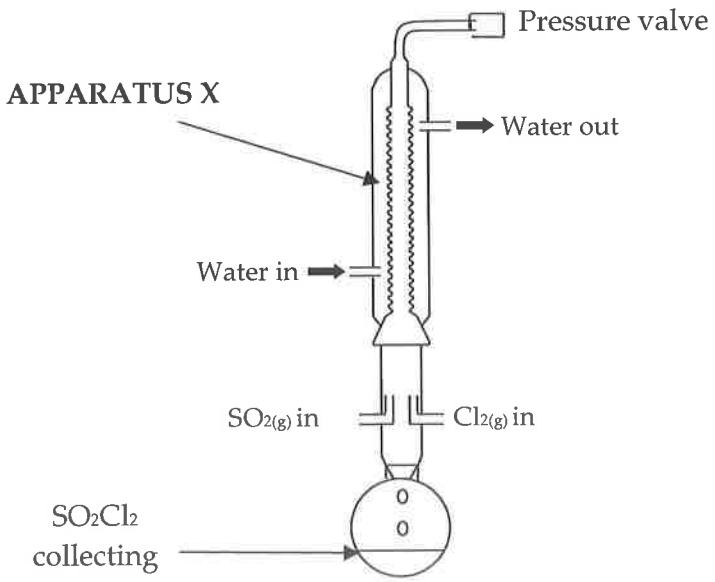
e) The reaction takes place in a vessel, as shown in Figure 1.

FIGURE 1



STAGE 1

- SO_2 and Cl_2 gases are passed into apparatus X
- They react to form SO_2Cl_2
- SO_2Cl_2 collects at the bottom of the flask

STAGE 2

- After a period of time, the flask of SO_2Cl_2 is removed, then connected to distillation apparatus.
- The SO_2Cl_2 is heated to its boiling point and is distilled into a different flask.

i) Explain why this experiment would be carried out in a fume cupboard.

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[1]

ii) Suggest the name and purpose of Apparatus X.

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[2]

iii) Explain the purpose of Stage 2.

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[2]

QUESTION TOTAL: 20 MARKS

19 Colorimetry is an important technique that can be used to investigate a wider variety of chemical reactions that involve colour changes. These reactions can then be repeated with a catalyst and the colorimetry results used to determine how effective a catalyst is.

a) i) Explain how a catalyst works.

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[2]

ii) Identify two potential disadvantages of using a catalyst in an industrial process.

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[2]

b) Alternatively, instead of studying catalysis, colorimetry can be used to study the rate of air oxidation of Fe^{2+} to Fe^{3+}, which is important for understanding rusting.

Using a colorimeter, the concentration of $Fe^{3+}_{(aq)}$ formed can be estimated and a plot of concentration against time drawn.

Plot the following data on the graph paper overleaf, and determine the rate of reaction at 300 seconds, giving the unit.

Time (s)	$[Fe(H_2O)_6]^{3+}_{(aq)}$ (mol dm^{-3})
0	0.00
120	4.60×10^{-3}
240	8.00×10^{-3}
360	1.04×10^{-2}
480	1.24×10^{-2}
600	1.40×10^{-2}

[6]

c) i) How could half-lives be used to confirm the air oxidation of $Fe^{2+}_{(aq)}$ is first order with respect to $Fe(H_2O)_6$?

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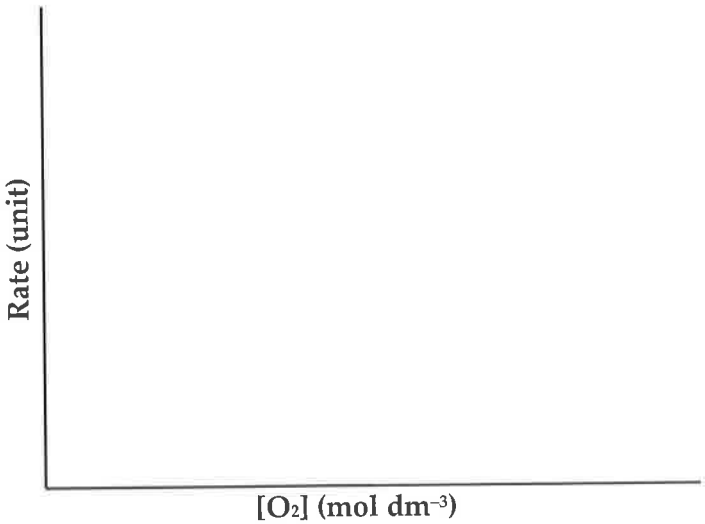
[2]

ii) The reaction is zeroth order with respect to $[O_2]$. Sketch the shape of a rate against $[O_2]$ graph on the axes below.



[1]

d) Explain why it is necessary to calibrate a colorimeter before using it, and explain how the calibration would be done.

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[3]

QUESTION TOTAL: 16 MARKS

20* The chemistry of transition metal solutions and complexes is varied, and includes:

- ligand substitution reactions
- redox reactions
- precipitation reactions

Describe what each of these reactions involves using example equations for reactions of Cu^{2+} or Fe^{2+} solutions or complexes, and give an example of the importance of each type of reaction that involves either Cu^{2+} or Fe^{2+} ions.

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[6]

QUESTION TOTAL 6 MARKS

21 Lithium fluoride is a crystalline solid that is used as in X-rays and LEDs. It has the second most exothermic lattice enthalpy of any compound for a given mass of starting material. The following data can be used to calculate the lattice energy.

	Enthalpy Change (kJ mol^{-1})
1st Ionisation Energy (Li)	+520
1st Electron Affinity (F)	-326
Enthalpy of Formation ($LiF_{(s)}$)	-616
Enthalpy of Atomisation ($F_{(g)}$)	+79
Enthalpy of Atomisation ($Li_{(s)}$)	+158

a) Describe the bonding in lithium fluoride.

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(2)

b) Define the term 'lattice enthalpy'.

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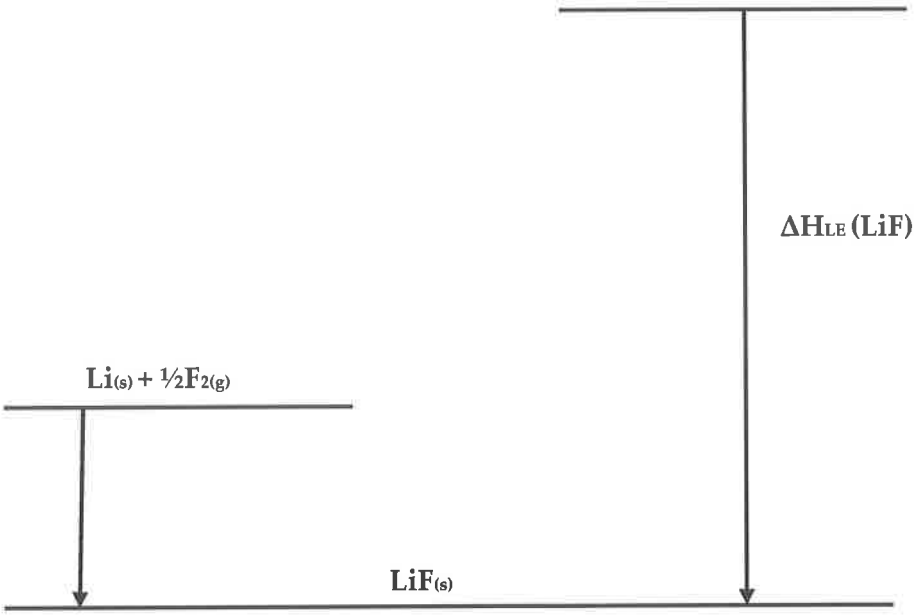
[2]

c) Complete the Born–Haber cycle for lithium fluoride below, labelling the enthalpy changes, and use the data above to calculate the lattice enthalpy of lithium fluoride.



[6]

d) Beryllium oxide, BeO, has the most exothermic lattice enthalpy for a given mass of substance. Explain why BeO has a more exothermic lattice enthalpy than LiF for a given mass of reactant.

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[2]

e) A student suggested that $LiF_{(s)}$ would be more soluble in water than $NaCl_{(s)}$ because the enthalpy of hydration of $Li^+_{(g)}$ and $F^-_{(g)}$ would be more exothermic than the enthalpies of hydration of $Na^+_{(g)}$ and $Cl^-_{(g)}$. In fact, the enthalpy of solutions of lithium fluoride and sodium chloride are as follows:

Enthalpy of solution (LiF) = 4.73 kJ mol^{-1}

Enthalpy of solution (NaCl) = 3.88 kJ mol^{-1}

Suggest, by referring to enthalpy terms only, why the student's prediction was incorrect.

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[2]

f) Between the temperatures of 273 K and 373 K , the dissolution of lithium fluoride is feasible. By considering the linear nature of the equation $\Delta G = \Delta H - T\Delta S$, sketch a graph of ΔG against T over this temperature range, and explain your answer.

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[3]

QUESTION TOTAL: 17 MARKS

