MARKS I DROPPED: CHEMISTRY

TT REVISION METHOD™ [OCR A LEVEL GAMMA 2022 PAPER 1]

Test Conditions → Negatively Mark & Analyse → FFS Journal → Action Hours → Repeat Paper

QUESTION & MARKS	MID TALLY FFS	TOPICS	MID KNOWLW DGE	MID TALLY PRACTICE	NOTES
Q 1-15 15 Marks	1ST / 2ND	Multiple Choice			
Q 16 7 Marks		Enthalpy of Combustion, Enthalpy & Entropy, Enthalpy of Combustion Calculation			
Q 17 15 Marks		Transition Metals, Transition Metal Complexes, Inorganic Identification Calculation			
Q 18 15 Marks		Group 2			
Q 19 14 Marks		Enthalpy Practical, Redox			
Q 20 16 Marks		Acids & Bases, Making a Standard Solution, Acids & Bases Calculation			
Q 21 13 Marks		Mole Calcs & PV=nRT			
Q 22 7 Marks		Rates, Rates Calculation			

SECTION A

You should spend a maximum of 20 minutes on this section.

Write your answer to each question in the box provided.

Answer **all** the questions.

1 A sample of boron contains the isotopes ^{10}B and ^{11}B.
The relative atomic mass of the boron sample is 10.8.

What is the percentage of ^{11}B atoms in the sample of boron?

A 8.0%

B 20%

C 80%

D 92%

Your answer ☐ **[1]**

2 In the compound $[ICl_2]^+ [SbCl_6]^-$, the oxidation number of chlorine is –1.

What are the oxidation numbers of I and Sb in the compound?

	I	Sb
A	+1	+5
B	+1	+7
C	+3	+5
D	+3	+7

Your answer ☐ **[1]**

3 What is the number of hydrogen atoms in 0.125 mol of C_2H_5OH?

A 7.525×10^{22}

B 4.515×10^{23}

C 3.7625×10^{23}

D 3.612×10^{24}

Your answer ☐ **[1]**

4 A student titrates a standard solution of barium hydroxide, $Ba(OH)_2$, with nitric acid, HNO_3.

$25.00\,cm^3$ of $0.0450\,mol\,dm^{-3}$ $Ba(OH)_2$ are needed to neutralise $23.35\,cm^3$ of $HNO_3(aq)$.

What is the concentration, in $mol\,dm^{-3}$, of the nitric acid?

A 0.0241

B 0.0482

C 0.0900

D 0.0964

Your answer ☐ **[1]**

5 Which statement best explains why nitrogen has a larger first ionisation energy than oxygen?

A N atoms have less repulsion between p-orbital electrons than O atoms.

B N atoms have a smaller nuclear charge than O atoms.

C N atoms lose an electron from the 2s subshell, while O atoms lose an electron from the 2p subshell.

D N atoms have an odd number of electrons, while O atoms have an even number.

Your answer ☐ **[1]**

6 In the Periodic Table, element **X** is in Group 2 and element **Y** is in Group 15 (5).

What is the likely formula of an ionic compound of **X** and **Y**?

A $\mathbf{X_2Y_5}$

B $\mathbf{X_2Y_3}$

C $\mathbf{X_3Y_2}$

D $\mathbf{X_5Y_2}$

Your answer ☐ **[1]**

7 Which statement about ammonium carbonate is **not** correct?

A It reacts with $Ba(NO_3)_2(aq)$ to form a white precipitate.

B It effervesces with dilute nitric acid.

C It release an alkaline gas with warm NaOH(aq).

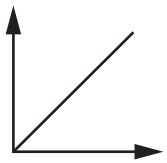
D It has the formula NH_4CO_3.

Your answer ☐ **[1]**

8 A reaction is first order with respect to a reactant **X**.

Which rate–concentration graph for reactant **X** is the correct shape?

A



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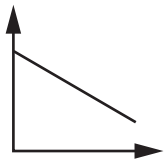

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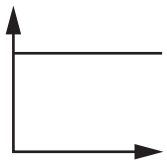

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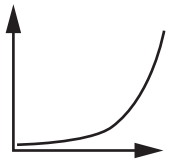


Your answer ☐ **[1]**

9 The reversible reaction of sulfur dioxide and oxygen to form sulfur trioxide is shown below.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

An equilibrium mixture contains 2.4 mol SO_2, 1.2 mol O_2 and 0.4 mol SO_3.
The total pressure is 250 atm.

What is the partial pressure of SO_3?

A 15 atm

B 25 atm

C 100 atm

D 200 atm

Your answer ☐ **[1]**

10 A buffer solution is prepared by mixing 200 cm^3 of 2.00 mol dm^{-3} propanoic acid, CH_3CH_2COOH, with 600 cm^3 of 1.00 mol dm^{-3} sodium propanoate, CH_3CH_2COONa.

K_a for $CH_3CH_2COOH = 1.32 \times 10^{-5}$ mol dm^{-3}

What is the pH of the buffer solution?

A 4.58

B 4.70

C 5.06

D 5.18

Your answer ☐ **[1]**

11 The table below shows standard entropies, $S^{\ominus}$.

Substance	CO(g)	$H_2(g)$	$CH_3OH(l)$
$S^{\ominus}$ / J mol^{-1} K^{-1}	197.6	130.6	239.7

What is the entropy change, $\Delta S^{\ominus}$, in J mol^{-1} K^{-1}, for the following reaction?

$$CO(g) + 2H_2(g) \rightarrow CH_3OH(l)$$

A –219.1

B –88.5

C +88.5

D +219.1

Your answer ☐ **[1]**

12 The redox equilibria for a hydrogen–oxygen fuel cell in alkaline solution are shown below.

$2H_2O(l) + 2e^- \rightleftharpoons H_2(g) + 2OH^-(aq)$ $\quad E^{\ominus} = -0.83\,V$

$^1/_2O_2(g) + H_2O(l) + 2e^- \rightleftharpoons 2OH^-(aq)$ $\quad E^{\ominus} = +0.40\,V$

What is the equation for the overall cell reaction?

A $H_2(g) + 4OH^-(aq) \rightarrow 3H_2O(l) + {}^1/_2O_2(g)$

B $3H_2O(l) + {}^1/_2O_2 \rightarrow H_2(g) + 4OH^-(aq)$

C $H_2O(l) \rightarrow H_2(g) + {}^1/_2O_2(g)$

D $H_2(g) + {}^1/_2O_2(g) \rightarrow H_2O(l)$

Your answer ☐ **[1]**

13 Which enthalpy change(s) is/are endothermic?

1 The bond enthalpy of the C–H bond

2 The second electron affinity of oxygen

3 The standard enthalpy change of formation of magnesium

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐ **[1]**

14 Which statement(s) explain(s) why reaction rates increase as temperature increases?

1 The activation energy is less.

2 Collisions between molecules are more frequent.

3 A greater proportion of molecules have energy greater than the activation energy.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer ☐ **[1]**

15 Which statement(s) is/are correct for the complex $Pt(NH_3)_2Cl_2$?

1 One of its stereoisomers is used as an anti-cancer drug.

2 It has bond angles of 109.5°.

3 It has optical isomers.

A 1, 2 and 3

B Only 1 and 2

C Only 2 and 3

D Only 1

Your answer [ ] **[1]**

16 A student is asked to calculate ΔG at 25 ºC for the combustion of butan-1-ol. The teacher provides two pieces of information.

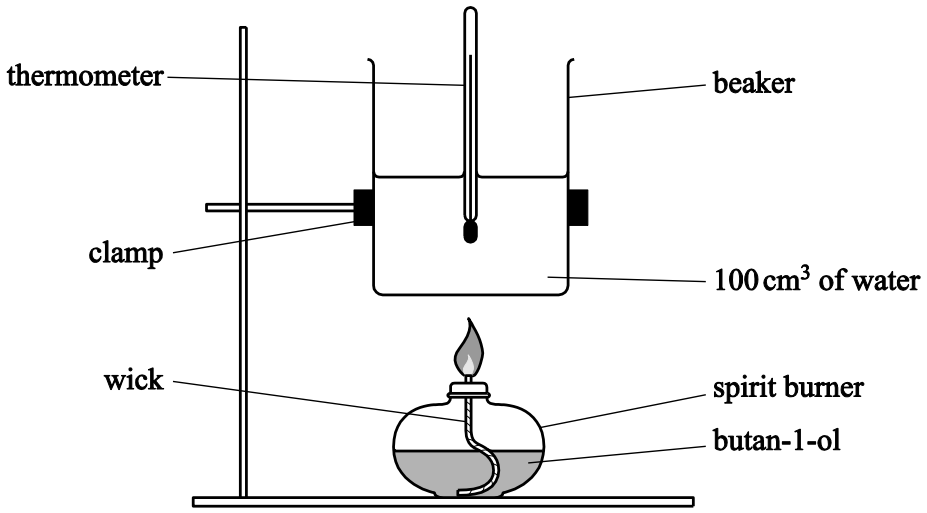
- The equation for the combustion of butan-1-ol.

$$CH_3(CH_2)_3OH(l) + 6O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l) \qquad \textbf{Equation 2}$$

- Standard entropies of butan-1-ol, oxygen, carbon dioxide and water.

	$CH_3(CH_2)_3OH(l)$	$O_2(g)$	$CO_2(g)$	$H_2O(l)$
$S^{\ominus}$**/ J K^{-1} mol^{-1}**	228	205	214	70

The student carries out an experiment using the apparatus below and obtains the following results.
The specific heat capacity of water is 4.18 J g^{-1} K^{-1}.



Mass of burner and butan-1-ol before burning / g	98.997
Mass of burner and butan-1-ol after burning / g	98.738
Initial temperature / ºC	18.5
Maximum temperature reached / ºC	39.0

Use the information on the previous page to calculate ΔG, in kJ mol^{-1}, for the combustion of butan-1-ol according to **Equation 2** at 25 °C.

Show **all** your working.

ΔG = ... kJ mol^{-1} **[7]**

17 A student carries out a number of experiments on transition metal compounds.

4.800 g of a green hydrated crystalline solid **A** are heated in a crucible to remove the water of crystallisation. 1.944 g of water are removed to leave 0.0180 mol of solid residue **B**.

Solid **B** contains 32.8%, by mass, of the transition metal.

All of **B** is reacted with $AgNO_3(aq)$ to form 7.695 g of a white precipitate, **C**.

The green crystalline solid **A** is dissolved in water to produce a green solution containing a complex ion, **D**.

When aqueous sodium hydroxide is added to solution of **D**, a grey–green precipitate, **E**, is observed, which dissolves in excess aqueous sodium hydroxide to form a green solution.

(a) Determine the formulae of **A, B, D** and **E**.

Show **all** your working.

A = …… **D = ……**

B = …… **E = ……** **[9]**

(b)* Transition metal complexes often have different shapes and may form a number of stereoisomers.

Describe the different shapes and the different types of stereoisomerism found in transition metal chemistry.

Use suitable examples and diagrams in your answer.

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..... **[6]**

SECTION B

Answer **all** the questions.

18 Sir Humphry Davy discovered several elements including sodium, potassium, magnesium, calcium and strontium.

(a) Explain which block in the Periodic Table sodium and magnesium belong to.

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

(b) A sample of magnesium, A_r = 24.305, is found to consist of three isotopes. The accurate relative isotopic masses and % abundances of two of the isotopes are shown in the table.

Isotope	Relative isotopic mass	% abundance
^{24}Mg	23.985	78.99%
^{25}Mg	24.986	10.00%

Determine the relative isotopic mass of the third isotope of magnesium in the sample.

Give your answer to **5** significant figures.

relative isotopic mass = ... **[2]**

(c) A student adds an excess of calcium oxide to water in a test tube.
In a separate test tube, the student adds an excess of strontium oxide to water.

(i) Write the equation for the reaction of calcium oxide with water.

State symbols are **not** required.

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

(ii) Suggest the approximate pH of the two solutions formed in the test tubes.

pH with calcium oxide .....

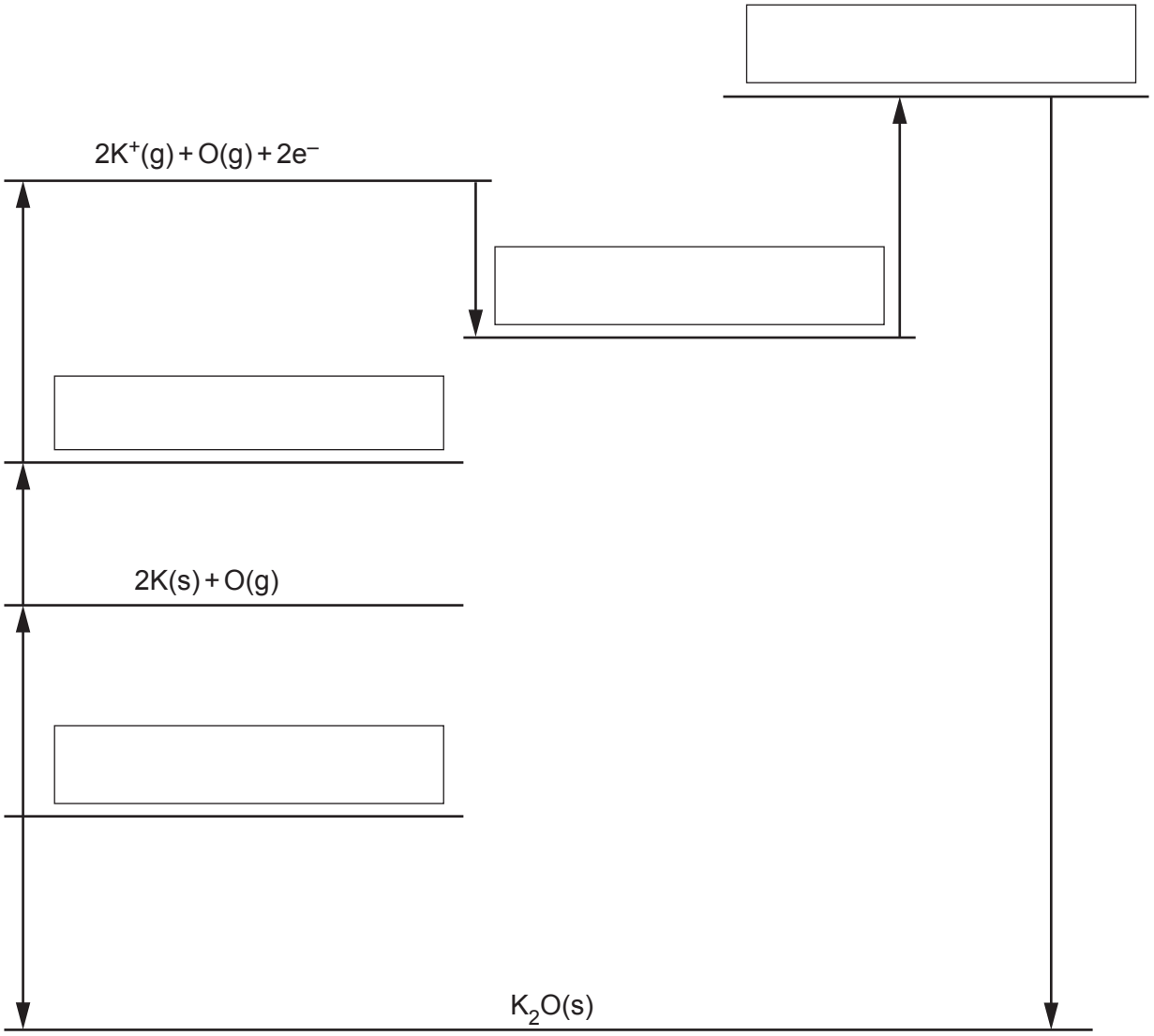
pH with strontium oxide.....
[1]

(d) The table below shows enthalpy changes involving potassium, oxygen and potassium oxide, K_2O.

	Enthalpy change / kJ mol^{-1}
formation of potassium oxide	–363
1st electron affinity of oxygen	–141
2nd electron affinity of oxygen	+790
1st ionisation energy of potassium	+419
atomisation of oxygen	+249
atomisation of potassium	+89

(i) The incomplete Born–Haber cycle below can be used to determine the lattice enthalpy of potassium oxide.

In the boxes, complete the species present in the cycle.
Include state symbols for the species.



[4]

(ii) Calculate the lattice enthalpy of potassium oxide.

lattice enthalpy = ... $kJ\,mol^{-1}$ **[2]**

(e) A similar Born–Haber cycle to potassium oxide in **(d)** can be constructed for sodium oxide.

(i) The first ionisation energy of sodium is more endothermic than that of potassium.

Explain why.

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..... **[2]**

(ii) The lattice enthalpy of sodium oxide is more exothermic than that of potassium oxide.

Explain why.

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..... **[2]**

19 A student plans to determine the enthalpy change of **reaction 3.1** shown below.

$$Na_2O(s) + 2HCl(aq) \rightarrow 2NaCl(aq) + H_2O(l) \qquad \textbf{reaction 3.1}$$

This enthalpy change can be determined indirectly using Hess' Law from the enthalpy changes of **reaction 3.2** and **reaction 3.3** shown below.

$$Na_2O(s) + H_2O(l) \rightarrow 2NaOH(aq) \qquad \textbf{reaction 3.2}$$

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l) \quad \Delta_r H = -57.6\,kJ\,mol^{-1} \qquad \textbf{reaction 3.3}$$

The student will determine the enthalpy change of **reaction 3.2** as outlined below.

- Weigh a bottle containing $Na_2O(s)$ and weigh a polystyrene cup.
- Add about $25\,cm^3$ of water to the polystyrene cup and measure its temperature.
- Add the $Na_2O(s)$, stir the mixture, and measure the maximum temperature reached.
- Weigh the empty bottle and weigh the polystyrene cup with the final solution.

Mass readings

Mass of bottle + $Na_2O(s)$	= 16.58 g
Mass of empty bottle	= 15.34 g
Mass of empty polystyrene cup	= 21.58 g
Mass of polystyrene cup + final solution	= 47.33 g

Temperature readings

Initial temperature of water	= 20.5 °C
Maximum temperature of final solution	= 55.5 °C

The density and specific heat capacity, *c*, of the solution are the same as for water.

(a)* Calculate the enthalpy change of **reaction 3.2** and the enthalpy change of **reaction 3.1**.

Show all your working.

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..... **[6]**

(b) The uncertainty in each temperature reading is ±0.1 °C.

The uncertainty in each mass reading is ±0.005 g.

Determine whether the mass of Na_2O or the temperature change has the greater percentage uncertainty.

Show all your working.

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..... **[2]**

(c) Suggest a modification to this experiment, using the **same** apparatus, which would reduce the percentage errors in the measurements.

Explain your reasoning.

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..... **[2]**

(d) Sodium oxide, Na_2O, can be prepared by the redox reaction of $NaNO_2$ and sodium metal. Nitrogen gas is also formed.

(i) What is the systematic name for $NaNO_2$?

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

(ii) Using oxidation numbers, with signs, show the element that is oxidised and the element that is reduced in this reaction.

Element oxidised .....

Oxidation number change from ..... to .....

Element reduced .....

Oxidation number change from ..... to .....

[2]

(iii) Construct the equation for this reaction.

Equation ..... **[1]**

20 A student investigates the reactions of two weak monobasic acids: 2-hydroxypropanoic acid, $CH_3CH(OH)COOH$, and butanoic acid, $CH_3CH_2CH_2COOH$.

(a) The student wants to prepare a standard solution of 2-hydroxypropanoic acid that has a pH of 2.19.

Plan how the student could prepare 250 cm^3 of this standard solution from solid 2-hydroxypropanoic acid.

In your answer you should provide detail of the practical procedure that would be carried out, including appropriate quantities and necessary calculations.

K_a for 2-hydroxypropanoic acid is 1.38×10^{-4} mol dm^{-3} at 25 °C.

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…… **[8]**

(b) 2-Hydroxypropanoic acid is a slightly stronger acid than butanoic acid. The two acids are mixed together and an acid–base equilibrium is set up.

Suggest the equilibrium equation and identify the conjugate acid–base pairs.

$CH_3CH(OH)COOH + CH_3CH_2CH_2COOH \rightleftharpoons$ .....

[2]

(c) To prepare a buffer solution, 75.0 cm^3 of 0.220 mol dm^{-3} butanoic acid is reacted with 50.0 cm^3 of 0.185 mol dm^{-3} sodium hydroxide.

K_a for butanoic acid is 1.5×10^{-5} mol dm^{-3} at 25 °C.

(i) Calculate the pH of 0.185 mol dm^{-3} sodium hydroxide at 25 °C.

Give your answer to **two** decimal places.

pH = ... **[2]**

(ii) Calculate the pH of the buffer solution at 25 °C.

Give your answer to **two** decimal places.

Show **all** your working.

pH = ... **[4]**

21 This question is about compounds of magnesium and phosphorus.

(a) A student plans to prepare magnesium phosphate using the redox reaction of magnesium with phosphoric acid, H_3PO_4.

$$3Mg(s) + 2H_3PO_4(aq) \rightarrow Mg_3(PO_4)_2(s) + 3H_2(g)$$

(i) In terms of the number of electrons transferred, explain whether magnesium is being oxidised or reduced.

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

(ii) The student plans to add magnesium to 50.0 cm^3 of 1.24 $mol\,dm^{-3}$ H_3PO_4.

Calculate the mass of magnesium that the student should add to react exactly with the phosphoric acid.

Give your answer to **three** significant figures.

mass of Mg = ... g **[3]**

(iii) How could the student obtain a sample of magnesium phosphate after reacting magnesium with phosphoric acid?

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..... **[2]**

(iv) Magnesium phosphate can also be prepared by reacting phosphoric acid with a compound of magnesium.

Choose a suitable magnesium compound for this preparation and write the equation for the reaction.

Formula of compound .....

Equation ..... **[2]**

(b) Phosphine, PH_3, is a gas formed by heating phosphorous acid, H_3PO_3, in the absence of air.

$$4H_3PO_3(s) \rightarrow PH_3(g) + 3H_3PO_4(s)$$

(i) 3.20×10^{-2} mol of H_3PO_3 is completely decomposed by this reaction.

Calculate the volume of phosphine gas formed, in cm^3, at 100 kPa pressure and 200 °C.

volume of PH_3 = ... cm^3 **[4]**

(ii) When exposed to air, phosphine spontaneously ignites, forming P_4O_{10} and water.

Construct an equation for this reaction.

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

22 Iodine monochloride, ICl, can react with hydrogen to form iodine.

$$2ICl + H_2 \rightarrow 2HCl + I_2$$

This reaction was carried out several times using different concentrations of ICl or H_2. The initial rate of each experiment was calculated and the results are shown below. Initial concentrations are shown for each experiment.

	[ICl] / mol dm^{-3}	**[H_2] / mol dm^{-3}**	**Rate / mol dm^{-3} s^{-1}**
Experiment 1	0.250	0.500	2.04×10^{-2}
Experiment 2	0.500	0.500	4.08×10^{-2}
Experiment 3	0.125	0.250	5.10×10^{-3}

(a) (i) Calculate the rate constant, *k*, for this reaction. Include units in your answer.

Show **all** your working.

k = ... units ..... **[4]**

(ii) Calculate the rate of reaction when ICl has a concentration of 3.00×10^{-3} mol dm^{-3} and H_2 has a concentration of 2.00×10^{-3} mol dm^{-3}.

Show **all** your working.

rate = ... mol dm^{-3} s^{-1} **[1]**

(b) Reaction rates can be increased or decreased by changing the temperature of the reaction. **Fig. 17.1** below shows the energy distribution of the reactant molecules at 25 °C.

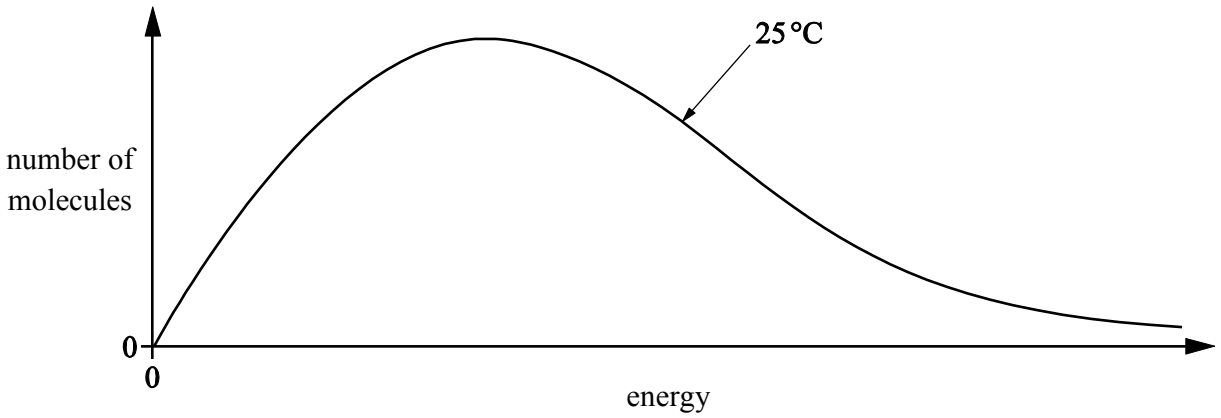

Fig. 17.1

Draw a second curve on **Fig. 17.1**, to represent the distribution of the same number of molecules at a higher temperature.

Use your curve to explain how increasing the temperature increases the rate of reaction.

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…… **[2]**