Year 11 Semester One Examination, 2018

Question/Answer Booklet

Marks		
Section 1	/40	
Section 2	/60	
Section 3	/65	
Total	**/165**	**%**

CHEMISTRY ATAR UNIT 1

Name: **ANSWERS**

Teacher: Ms Brown Ms Goodwin

CANDIDATES MUST WRITE IN BLUE OR BLACK INK THROUGHOUT THIS EXAM.

TIME ALLOWED FOR THIS PAPER
Reading time before commencing work: ten minutes
Working time for the paper: two and a half hours

MATERIALS REQUIRED/RECOMMENDED FOR THIS PAPER

To be provided by the supervisor:
This Question/Answer Booklet
Multiple-choice Answer Sheet
Chemistry Data Book

To be provided by the candidate:
Standard items: pens (blue/black preferred), pencils (including coloured), sharpener, eraser, correction tape/fluid, ruler, highlighters

Special items: up to three non-programmable calculators approved for use in the WACE examinations.

IMPORTANT NOTE TO CANDIDATES
No other items may be taken into the examination room. It is **your** responsibility to ensure that you do not have any unauthorised notes or other items of a non-personal nature in the examination room. If you have any unauthorised material with you, hand it to the supervisor **before** reading any further.

Structure of this paper

Section	Suggested working time (Minutes)	Number of questions available	Number of questions to be attempted	Approx. % of all marks (rounded)	Marks	Your mark
ONE Multiple choice	38	20	All	25	40	
TWO Short response	53	9	All	35	60	
THREE Extended response	59	5	All	40	65	
	150			100	165	

Instructions to candidates

1. Answer the questions according to the following instructions.

   Section One: Answer all questions on the separate Multiple-choice Answer Sheet provided. For each question shade the box to indicate your answer. **Use only a blue or black pen to shade the boxes.** If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

   Sections Two and Three: Write your answers in this Question/Answer Booklet.

2. When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

3. You must be careful to confine your responses to the specific questions asked and to follow any instructions that are specific to a particular question.

4. Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.
   - Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
   - Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

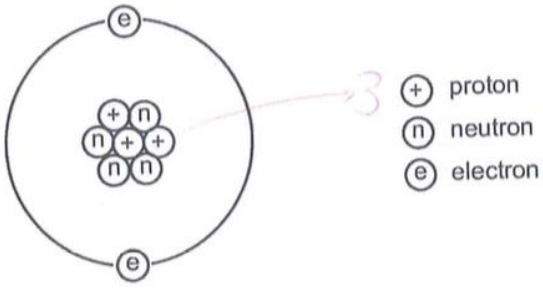
5. The Chemistry Data Book is **not** to be handed in with your Question/Answer Booklet.

Section One: Multiple-choice **24% (40 marks)**

This section has **20** questions. Answer **all** questions on the separate Multiple-choice Answer Sheet provided. For each question, shade the box to indicate your answer. Use only a blue or black pen to shade the boxes. If you make a mistake, place a cross through that square then shade your new answer. Do not erase or use correction fluid/tape. Marks will not be deducted for incorrect answers. No marks will be given if more than one answer is completed for any question.

Suggested working time: 38 minutes.

1. What is the identity of this species?



3+, 2-
Li^{+1} ion.

(a) Helium atom
(b) Lithium atom — Not correct
(c) Helium ion
(d) Lithium ion ← This is the correct answer.

2. Covalent substances are generally not able to conduct electricity because

(a) their electrons are localised.
(b) their electrons are delocalised.
(c) their electrons are transferred.
(d) their electrons are shared.

3. Eight consecutive elements in the Periodic Table have the following first ionisation energies: → in a list (not necessarily in the same period!)

Ionisation Energies in kJ mol^{-1}							
707	833	870	1010	1170	376	502	540

One of the eight elements is a halogen. The first ionisation energy of the halogen is:

(a) 1170
(b) 1010
(c) 870
(d) 376

See Next Page

4. Which of the following formulas represents a substance that contains twice as much hydrogen as oxygen, and half as much carbon as oxygen?

(a) $C_4H_8O_6$
(b) $C_2H_6O_3$
(c) $C_3H_{12}O_6$
(d) $C_5H_{10}O_3$

C : O : H
1 : 2 : 4
C : H : O
1 : 4 : 2

5. The total number of protons and electrons in the hydrogencarbonate ion is

(a) 63
(b) 62
(c) 32
(d) 31

HCO_3^-

p	1+6+3×8	31
$\bar{e}$	1+6+3×8+e	32.

63

6. In which of the following combinations of 0.20 mol L^{-1} solutions will a green precipitate be formed?

(a) $CrC\ell_3$, $Cu(NO_3)_2$, Na_2SO_4
(b) $Fe(NO_3)_2$, $NaC\ell$, K_2SO_4
(c) $Ni(NO_3)_2$, $CuSO_4$, KOH
(d) $FeC\ell_3$, Na_2CO_3, NaOH

$Ni(OH)_2$

$CuCO_3$ → Cu et. soluble.
Ni^{2+} ppt's

7. Which element is found in group 15, period 5?

(a) Tin
(b) Antimony
(c) Polonium
(d) Bismuth

8. How many electrons are in the valence shell of the following species?

Full valence shell.

	Mg	Al^{3+}	O^{2-}	P
(a)	2 ✓	3	6	5 ✓
(b)	2 ✓	8 ✓	8 ✓	5 ✓
(c)	1	6	4	8
(d)	2	0	8	8

9. Which of the following isotopes is likely to be the **least** commonly occurring?

(a) carbon-12
(b) sulfur-32
(c) iron-55
(d) nitrogen-16

N
14·01
∴ likely mostly N-14.

See Next Page

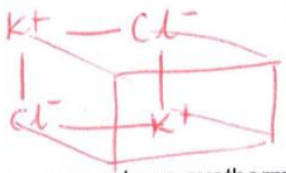
10. Which of the formulas below is **incorrect**?

(a) Ba_2F
(b) CaS
(c) Na_3P
(d) $AlCl_3$

Ba^{2+} F^{-1} → BaF_2

11. Which of the following substances is **not** able to conduct electricity?

(a) NaCl(aq)
(b) Au(s)
(c) KCl(s)
(d) Hg(l)



ions in fixed positions.
∴ no ion movement
∴ NO current/conductivity electricity

13. Which of these chemical equations represents an exothermic reaction?

(i) $CO + H_2O \rightarrow H_2 + CO_2 + 41\ kJ$ ✓Exo.
(ii) $CH_4 + H_2O \rightarrow CO + 3\ H_2 \quad \Delta H = +206\ kJ$ Endo.
(iii) $N_2O_3 + 40\ kJ \rightarrow NO + NO_2$ Endo.

(a) (i) only
(b) (ii) only
(c) (iii) only
(d) (ii) and (iii) only

14. Element X is in group 16 of the periodic table. Which of the following compounds is **least** likely to form?

O, S, ...
O^{2-} S^{2-}

(a) H_2X
(b) NaX
(c) MgX
(d) F_2X

15. Ionic substances are brittle because

(a) electrons have been transferred between species.
(b) electrons are shared between species.
(c) they are solids at room temperature.
(d) the charged species are arranged in a rigid lattice.

if ions are forced by pressure, they line up ⊕ to ⊕ & ⊖ to ⊖
↓
Na+ Cl- Na+ repulsion
Cl- Na+ Cl-
Na+ ↓
Shatter

16. What are the coefficients in this equation once correctly balanced?

$\_4\_\ NH_3(g) + \_5\_\ O_2(g) \rightarrow \_4\_\ NO(g) + \_6\_\ H_2O(l)$

(a) 2, 2, 2, 3
(b) 1, 3, 1, 2
(c) 4, 2, 3, 5
(d) 4, 5, 4, 6

See Next Page

17. Which of the following contains the greatest number of atoms?

(a) 3.0 g of Pb
(b) 0.01 mol of Ca
(c) 0.005 mol of NaCl
(d) 0.28 g NO_2

18. Which of the following are covalent compounds?

(i) Hydrogen peroxide
(ii) Carbon monoxide
(iii) Potassium hydroxide
(iv) Copper(II) phosphate
(v) Sulfurous acid

(a) (i), (ii) and (v) only
(b) (ii) and (v) only
(c) (i) and (ii) only
(d) (ii), (iii) and (v) only

Questions 19 and 20 relate to three common allotropes of carbon; diamond, graphite and fullerenes.

Consider the list of physical properties given below.

(i) Conductor of electricity
(ii) High melting point
(iii) Hard substance
(iv) Inert (unreactive) substance
(v) Atoms form a three dimensional network shape

19. Which of these properties correspond to diamond?

(a) (i), (ii) and (iv) only
(b) (ii), (iii) (iv) and (v) only
(c) (i), (iii) and (v) only
(d) (ii), (iii) and (v) only

20. Which of these properties correspond to graphite?

(a) (i) and (iv) only
(b) (ii) and (v) only
(c) (i), (ii) and (iv) only
(d) (i), (iii) and (v) only

End of Section One

See Next Page

Answer to Q 12, which was added later, previously missing.

12. Use the table to identify a pair of isotopes.

Element	Number of protons	Number of electrons	Number of neutrons
W	20	21	21
X	19	18	19
Y	19	21	19
Z	20	19	20

(a) Elements X and W

(b) Elements X and Y

(c) Elements W and Z

(d) Elements Y and W

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Yr. 11 Chemistry ATAR Unit 1
Semester 1, 2018.
Multiple-choice Answer Sheet

Name: ANSWERS (corrected)

INSTRUCTIONS: Pease write in blue or black pen.

For each question shade the box to indicate your answer.
Use **only** a blue or black **pen** to shade the boxes.

For example, if b is your answer: a ☐ b ■ c ☐ d ☐

If you make a mistake, place a cross through that square and shade your new answer. **Do not** erase or use correction fluid/tape.

For example, if b is a mistake and d is your answer: a ☐ b ☒ c ☐ d ■

If you then want to use your first answer b, cross out d and then circle b.

a ☐ b ◉ c ☐ d ☒

Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.

1	a ☐ b ☐ c ☐ d ▨
2	a ▨ b ☐ c ☐ d ☐
3	a ☐ b ▨ c ☐ d ☐
4	a ☐ b ☐ c ▨ d ☐
5	a ▨ b ☐ c ☐ d ☐

6	a ☐ b ☐ c ▨ d ☐
7	a ☐ b ☐ c ☐ d ▨
8	a ☐ b ▨ c ☐ d ☐
9	a ☐ b ☐ c ☐ d ▨
10	a ▨ b ☐ c ☐ d ☐

11	a ☐ b ☐ c ▨ d ☐
12	a ☐ b ☐ c ▨ d ☐
13	a ▨ b ☐ c ☐ d ☐
14	a ☐ b ▨ c ☐ d ☐
15	a ☐ b ☐ c ☐ d ▨

16	a ☐ b ☐ c ☐ d ▨
17	a ☐ b ☐ c ☐ d ▨
18	a ☐ b ☐ c ▨ d ☐
19	a ☐ b ▨ c ☐ d ☐
20	a ☐ b ☐ c ▨ d ☐

See Next Page

Section Two: Short answer **35% (60 marks)**

This section has **eleven (11)** questions. Answer **all** questions. Write your answers in the spaces provided.

When calculating numerical answers, show your working or reasoning clearly. Express numerical answers to the appropriate number of significant figures and include appropriate units where applicable.

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Suggested working time: 53 minutes.

Question 21 **(6 marks)**

Two sulfur-containing compounds that have very different properties are aluminium sulfate ($Al_2(SO_4)_3$) and sulfur trioxide (SO_3).
Explain, in terms of structure, bonding and melting point, why aluminium sulfate is a solid at room temperature, whereas sulfur trioxide is a gas at room temperature.

(You may include annotated diagrams to aid your explanation.)

(Max 1 for both bonding, if just state)

aluminium sulfate ($Al_2(SO_4)_3$)

- **aluminium sulfate is ionic**
- **strong electrostatic attraction between the cations and anions form rigid lattice**
- **large amount of heat required to disrupt the bonding, so melting point is high and therefore solid at room temperature**

Sulfur trioxide (SO_3). *(- 1 if no mention solid vs gas)*

- sulfur trioxide **is covalent molecular**
- **therefore there are only weak intermolecular forces between discrete molecules**
- **so much less heat is required to disrupt the weak intermolecular forces, so melting point is lower than room temperature, because it is already a gas at room temperature.**

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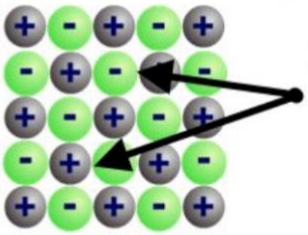
Diagrams – Suggestions:

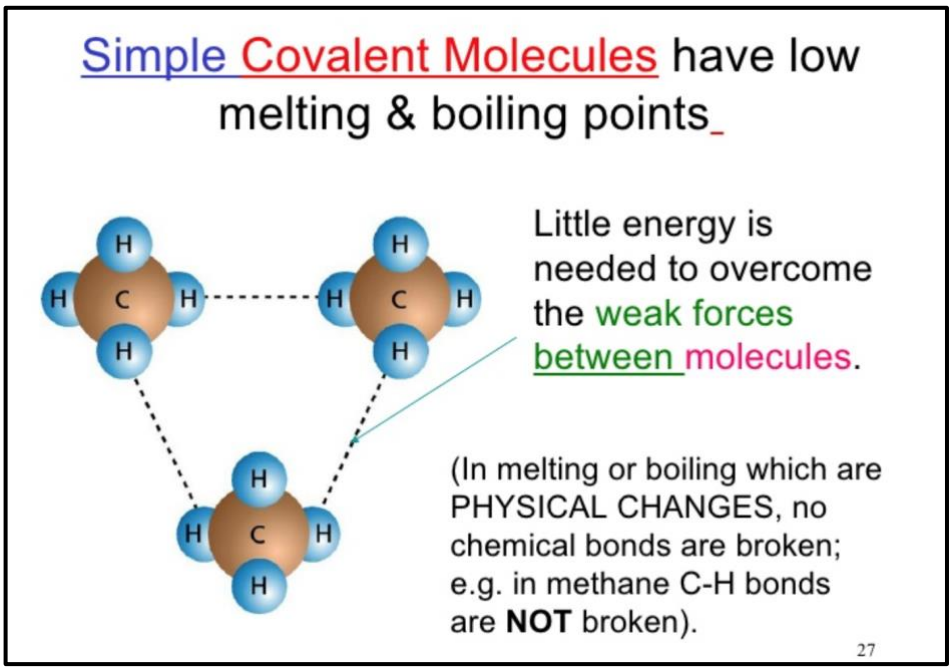
Ionic <u>aluminium sulfate ($Al_2(SO_4)_3$)</u>

Ionic bonds are strong and a lot of heat is needed to break them.



Larger ionic charges produce stronger ionic bonds and so much more heat is required to break the ionic bonds in **<u>aluminium sulfate ($Al_2(SO_4)_3$)</u>**

Covalent molecular - <u>Sulfur trioxide (SO_3).</u>



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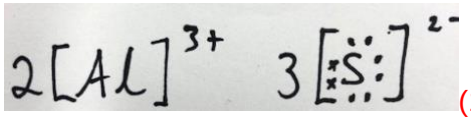
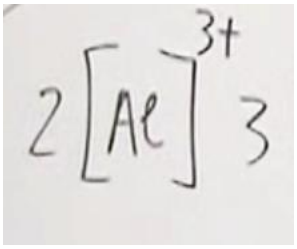
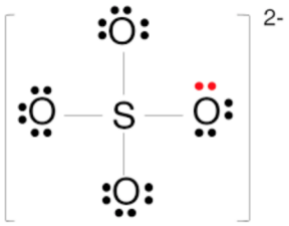
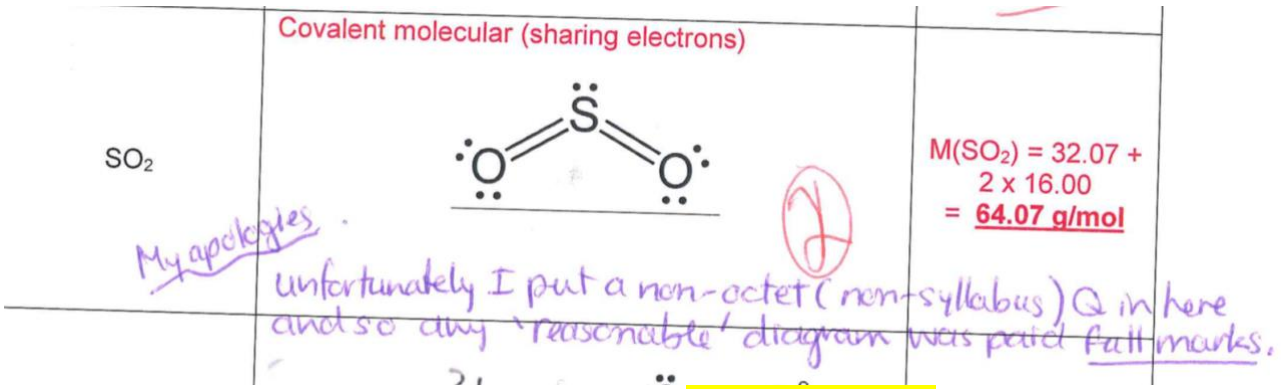
Question 22 **(8 marks)**

(a) Complete the table below by; (6 marks)

- drawing structural formulas showing **all bonds and atoms**, and
- writing the molecular formula for each organic molecule.

	Structural diagram	Molar Mass
Al_2S_3	Ionic (ions in fixed positions)  (1)	$M(Al_2S_3)$ = 2 x 26.98 + 3 x 32.07 = **150.17 g/mol** (1)
$Al_2(SO_4)_3$	  (2)	$M(Al_2(SO_4)_3)$ = 2 x 26.98 + 3 x 32.07 + 12 x 16.00 = **342.17 g/mol**



(b) Which of the compounds above contains the highest percentage of sulfur by mass? (2 marks)
Calculate this value. **Al_2S_3**

(must have working / % for each)

% S in Al_2S_3 = [3 M(S) / $M(Al_2S_3)$] x 100 = (3x32.07) / 150.17 = 96.21/150.17 = **64.1%**

% S in SO_2 = [M(S) / $M(SO_2)$] x 100 = 32.07 / **64.07** = 32.07 /**64.07** = **50.1%**

% S in $Al_2(SO_4)_3$ = [3 M(S) / $M(Al_2(SO_4)_3)$] x 100 = (3x32.07) / **342.17** = 96.21/**342.17** = **28.1%**

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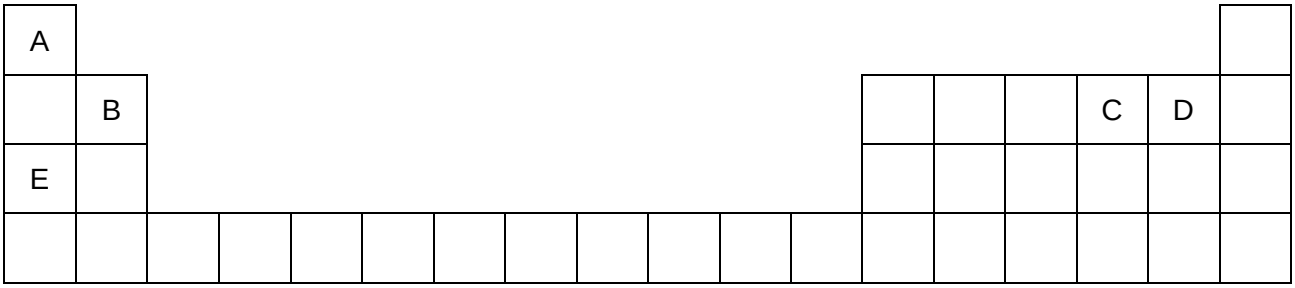
Question 23 **(8 marks)**

Consider the elements labelled A-E on the diagram below, which shows the first four periods of the periodic table.



(a) Why are A and E both in group 1? (1 mark)

both have one valence electron

(b) Why are B, C and D all in period 2? (1 mark)

all have electrons filling the second shell

(c) Why would atoms of element C and E form chemical bonds? State the type of compound formed and describe how the chemical bonds form. (3 marks)

- **By bonding, both elements would achieve a full, stable octet (E_2C or Na_2O)**
- **Ionic bonds / ionic compound would form**
- **E (sodium, 1 valence electrons) would donate electrons to C (oxygen, 6 valence electrons)**

(d) Why would atoms of element C and D form chemical bonds? State the type of compound formed and describe how the chemical bonds form. (3 marks)

- **By bonding, both elements would achieve a full, stable octet (D_2C / CD_2 or OF_2 / F_2O)**
- **Covalent compound / covalent molecule / covalent bonds would form**
- **C (oxygen, 6 valence electrons) and D (fluorine, 7 valence electrons) would share electrons** ***(stable octet 1)***

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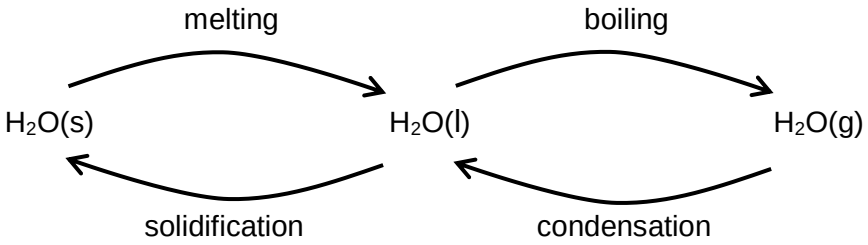
Question 24 **(6 marks)**

Consider the diagram below.



(a) Name one (1) of the labelled phase changes that is **endothermic**. Justify your choice. (3 marks)

- **melting OR boiling (1)**
- **both processes require an input of heat (1) (this increases both Ek and Ep) OR in both processes product has greater energy/enthalpy than reactant**
- **therefore ΔH is positive and reaction is endothermic (1)**

Bioluminescent Bay in Puerto Rico is a popular tourist attraction because of the microorganisms that live in the water. These types of organisms glow in the dark because they produce light by a special chemical reaction.

(b) Explain why this reaction is exothermic. (3 marks)

- **production of light by a chemical reaction means energy is released from system (1)**
- **therefore enthalpy of products lower than enthalpy of reactants (1)**
- **therefore ΔH is negative and reaction is exothermic. (1)**

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Question 25 **(8 marks)**

All matter can be classified as either pure substances or mixtures.

(a) Complete the table below by writing the name or formula of the compound, as well as classifying the compound as having consistent properties with either an ionic or covalent substance. (6 marks)

Name	Formula	Covalent or ionic properties
Ammonium carbonate	**$(NH_4)_2CO_3$**	**ionic**
Iron(III) nitrate	$Fe(NO_3)_3$	**ionic**
Ethanoic acid	**CH_3COOH**	**covalent**

The table above refers only to pure substances.

(b) State two (2) ways a mixture differs from a pure substance. (2 marks)

- **mixture has no fixed composition, no formula, variable properties, can more easily be separated, contains 2 or more different substances… any 2 relevant points**

Question 26 **(7 marks)**

Complete the table below, showing the subatomic particle arrangement of the four different species. (2 squares for correct = 1 mark, **except** in the final column where 1 box = 1 mark)

Symbol	Number of protons	Number of neutrons	Electron configuration	Electron energy configuration (s, p, d…)
^{19}F	**9**	**10**	**2, 7**	$1s^2, 2s^2\ 2p^5$
$^{23}Na^+$	11	12	2, 8	$1s^2, 2s^2\ 2p^6$
$^{32}S^{2-}$	16	16	**2, 8, 8**	$1s^2, 2s^2\ 2p^6, 3s^2\ 3p^6$
^{14}C	6	8	2, 4	$1s^2, 2s^2\ 2p^4$

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Question 27 **(7 marks)**

Salts containing the metal potassium (K) have a characteristic lilac (purple) colour in a flame test. A chemistry student was planning on performing flame tests on a series of different salt samples, **trying to find one that contained a rare isotope of potassium**. However, the student decided that the flame test would not be reliable as the isotope flame colour would be different from usual.

(a) What is an isotope? (2 marks)

- **atoms of an element that have the same number of protons but different numbers of neutrons**
- **atoms with the same atomic number but different mass number**
- **resulting in similar chemical properties but different physical properties**

… any 2 of these relevant points

(b) Was the student correct? Explain. (3 marks)

- **no**
- **flame tests depend on movement of <u>electrons</u>**
- **isotopes of potassium have the <u>same number of electrons</u> / same electron configuration, so flame test would give same result**

The relative atomic mass (Ar) of potassium is 39.10.

(c) What is the Ar of an element? What does it indicate that the Ar of potassium is close to the whole number of 39? (2 marks)

weighted average mass of all known isotopes of an element / average mass of an atom compared to 1/12th the mass of a C-12 / <u>average mass of an atom, weighted by abundance of all known isotopes</u>

- **major isotope / most abundant isotope of potassium likely to be <u>K-39</u>**

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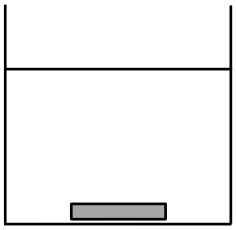
Question 28 **(6 marks)**

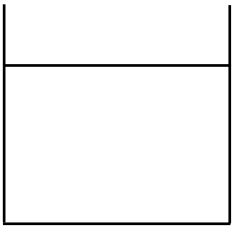
A student was conducting an experiment on the reaction between magnesium metal (Mg) and hydrochloric acid (HCl). Her experimental set up is shown below, as well as the measurements that she made during the investigation.

$$Mg(s) + 2\,HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

Start of experiment – Mg mixed with HCl



End of experiment – all Mg dissolved



Mass of empty beaker	34.5 g
Mass of Mg added	8.9 g
Mass of HCl added	43.1 g
Total mass of beaker at start of experiment	86.5 g

Total mass of beaker at end of experiment	85.8

(a) State the Law of Conservation of Mass and use this law to calculate the mass of hydrogen (loss in mass) gas produced in this experiment. You may assume the acid was in excess and all of the magnesium reacted. (3 marks)

- **Matter cannot be created or destroyed in a chemical reaction / total number of atoms present cannot change, only be rearranged**
- **Total mass at start = 86.5 g (may be written in table above)**
- **$m(H_2)$ = 86.5 – 85.8 = 0.7 g**

(b) If 8.9 g of magnesium was used in the experiment, as stated above, calculate the mass of hydrochloric acid that would have been consumed. (3 marks)

n(Mg) = m/M
= 8.9 / 24.31
= 0.366104 mol

$n(H_2)$ =m/M = 0.7/2.016 = 0.3472 mol

n(HCl) = 2 x n(Mg)
= 0.732209 mol

n(HCl) = 2 x $n(H_2)$ = 2 x 0.3472 = 0.6944 mol

m(HCl)= nM
= 0.732209 x 36.458
= 26.69 g ~ 26.7 g

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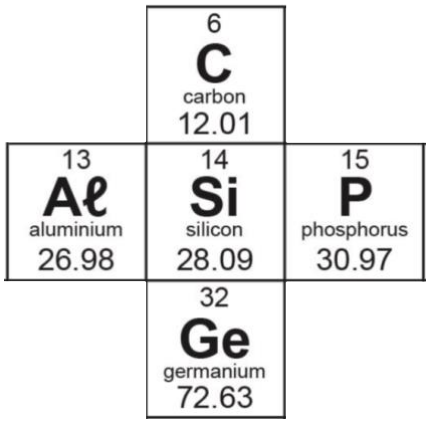
Question 29 **(4 marks)**

A portion of the periodic table, showing the elements surrounding silicon, is given below. Consider the five elements in the diagram.



(a) Of these elements, germanium has the largest atomic radius and the smallest first ionisation energy. Explain why, this statement is correct. (3 marks)

- **largest atomic radius because greatest number of electron shells filled**

- **lowest 1st ionisation energy because outermost electron is furthest from nucleus**
- **therefore requires lowest/smallest amount of energy to remove (also shielding of inner shells)**

(b) Which Period 3 element has the highest electronegativity? __**Chlorine**_____ (1 mark)

Q says to consider the (5) elements in the diagram, so we will accept P.

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Section Three: Extended answer **40% (65 marks)**

This section contains **five (5)** questions. You must answer **all** questions. Write your answers in the spaces provided below.

Where questions require an explanation and/or description, marks are awarded for the relevant chemical content and also for coherence and clarity of expression. Lists or dot points are unlikely to gain full marks.

Final answers to calculations should be expressed to the appropriate number of significant figures.

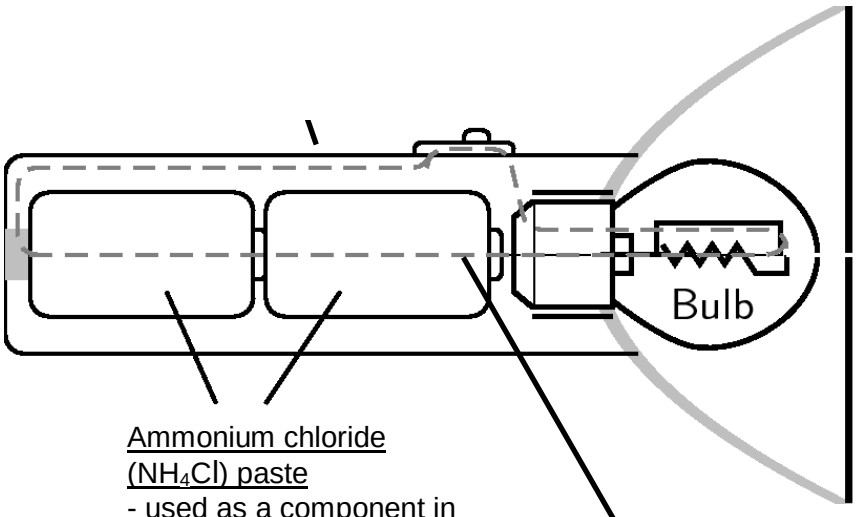
Spare pages are included at the end of this booklet. They can be used for planning your responses and/or as additional space if required to continue an answer.

- Planning: If you use the spare pages for planning, indicate this clearly at the top of the page.
- Continuing an answer: If you need to use the space to continue an answer, indicate in the original answer space where the answer is continued, i.e. give the page number. Fill in the number of the question(s) that you are continuing to answer at the top of the page.

Suggested working time: 59 minutes.

Question 30 **(11 marks)**

Study the following diagram of a torch (flashlight). Several components have been labelled and some information about the properties of these materials has also been included.



Glass / Silicon dioxide (SiO_2)
- used to protect the bulb because it is **hard** and **strong.**

Ammonium chloride (NH_4Cl) paste
- used as a component in batteries because it **conducts electricity.**

Copper (Cu)
- used for the wiring because it is **malleable** and **conducts electricity.**

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Explain why each of the labelled materials has been used in this torch.

Your answer should **focus on** the **type of bonding** present in each of the three (3) labelled components, as well as an explanation of their **main properties** (shown in **bold**), in terms of the structure and bonding present.

Many students lost easy marks by not stating the Bonding type, or,
by just "listing" the property but not **explaining** the property that was shown in **BOLD**.

For SiO_2

- **covalent network bonding (1)**
- **strong covalent bonding throughout entire 3-D network (1) must have 3-D for this mark.**
- **a large amount of force is required to disrupt to disrupt the covalent bonds, therefore *hard and strong***

For Cu

- **metallic bonding (1)**
- **sea of delocalised electrons throughout, which are mobile charged particles present (delocalised electrons) allow it to *conduct electricity* (1)**
- **non-directional bonding (1)**
- **force can be applied without breaking bonds / force can be applied to cause substance to change shape, therefore *ductile* (1)**

For NH_4Cl

- **ionic bonding (1)**
- **ions dissociate because it is paste / wet / (aq) must have dissociate for this mark, or explain how the ions became mobile rather than in fixed positions on a solid lattice. (1)**

No marks given for MOLTEN state as the torch battery paste would have to be very hot to make NH_4Cl molten!!! (like 334°C)

- **mobile charged particles present (ions) allow it to *conduct electricity*(1)**

Diagrams from Q 30 may be drawn here.

Diagrams need to be correctly labelled and annotated to detail the points given above, in order to gain marks.

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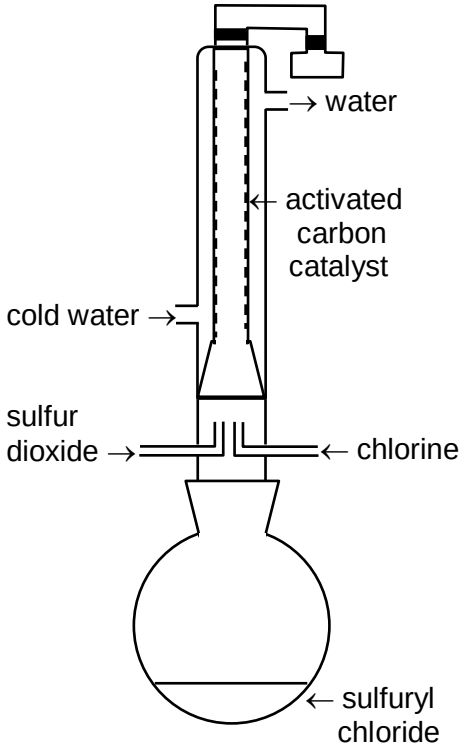
Question 31 **(9 marks)**

Sulfuryl chloride is a toxic, corrosive substance with a pungent odour. It isn't found in nature because it reacts quickly with water to produce a mixture of hydrochloric and sulfuric acids. Some information on sulfuryl chloride is shown in the table below.

Formula	SO_2Cl_2
Melting point	-54.1 °C
Boiling point	69.4 °C
Density	1.67 g mL^{-1}



Sulfuryl chloride can be made using the apparatus shown in the diagram to the right. **Sulfur dioxide** and **chlorine gases** are added into the glass reaction vessel. Here they react to form **sulfuryl chloride**. The inner tube of the reaction vessel is coated with an **activated carbon (C) catalyst**. This reaction is **exothermic**, so cold water is used to cool the glass reaction vessel and keep the temperature at around 30-40 °C.

(a) What phase (state) would sulfuryl chloride be when it forms, if the temperature of the reaction vessel is kept to around 30-40 °C? Justify your answer. (2 marks)

- **liquid**
- **30-40 °C is between the melting point and boiling point**

(b) Write a balanced molecular equation for the synthesis of sulfuryl chloride, as described in the reaction above. Include all **bolded** information, as well as phase (state) symbols, in your equation. (2 marks)

$$Cl_2(g) + SO_2(g) \xrightarrow{C} SO_2Cl_2(l) + \text{heat} \quad \text{OR} \quad \Delta H = \text{negative}$$

Minus (1) for any of the following errors:
(1) formulas/equation, (1) phase symbols need to be present, (1) exothermic

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(c) If 87.5 g of sulfur dioxide gas is added into the reaction vessel, what is the maximum mass of sulfuryl chloride that could be produced? (3 marks)

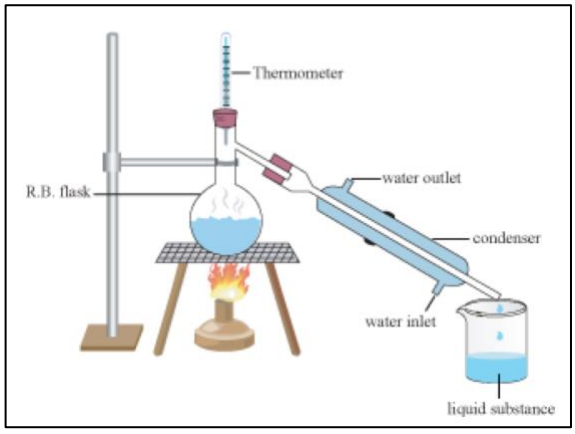
$n(SO_2)$ = m/M
= 87.5 / (32.07 + 2 x 16.00)
= 87.5 / 64.07
= 1.36569 mol (1)

$n(SO_2Cl_2)$ = $n(SO_2)$ = 1.36569 mol (1)

$m(SO_2Cl_2)$ = nM
= 1.36569 x (32.07 + 2 x 16.00 + 2 x 35.45)
= 1.36569 x 134.97
= 184.3 g (1)
~ 184 g (3sf)

This step was not well done by many. Please be careful to show correct chemistry, not just some "good math ratio". $n(SO_2Cl_2)$ = $n(SO_2)$ = 1.36569 mol (1)

Once sulfuryl chloride is produced, it is separated from the reaction mixture by distillation.
This is done by heating the reaction vessel to 68-70 °C and collecting the sulfuryl chloride fraction (component).
Distillation is a technique of separating a mixture based on the boiling point differences in the individual components of the mixture. See the diagram below.



(d) Why is a temperature of 68-70 °C chosen to separate the sulfuryl chloride during the distillation process? (2 marks)

- **this temp is around the boiling point of SO_2Cl_2 , so it will be just becoming gaseous at this point,**
- **allowing it to be separated from the liquid reaction mixture / water** (implies a liquid) **by distillation**

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Question 32 **(17 marks)**

Three groups of chemistry students (A, B and C) were investigating endothermic and exothermic reactions. Each group was given one reaction to study, as shown in the table below.

Group A	$HCl(aq) + NaHCO_3(aq) \rightarrow NaCl(aq) + CO_2(g) + H_2O(l)$
Group B	$CuSO_4(aq) + Mg(s) \rightarrow MgSO_4(aq) + Cu(s)$
Group C	$Ba(OH)_2(s) + 2\ NH_4SCN(s) \rightarrow Ba(SCN)_2(aq) + 2\ H_2O(l) + 2\ NH_3(g)$

Each group planned their experiment, with the aim to investigate whether their reaction was endothermic or exothermic. They mixed their reagents together in test tubes and recorded the initial temperature of the system, as well as the final temperature once the reaction was finished.

The incomplete results of each group are shown in the tables below.

Group A	**Trial 1**	**Trial 2**	**Trial 3**
Initial temp (°C)	20.5	20.0	21.5
Final temp (°C)	17.0	16.0	18.0
Temperature change (°C)	- 3.5	- 4.0	- 3.5

Group B	**Trial 1**	**Trial 2**	**Trial 3**
Initial temp (°C)	22.5	21.5	23.0
Final temp (°C)	25.0	26.5	26.5
Temperature change (°C)	+ 2.5	+ 5.0	+ 3.5

Group C	**Trial 1**	**Trial 2**	**Trial 3**
Initial temp (°C)	18.5	19.0	19.5
Final temp (°C)	4.0	5.5	**3.5** (1 mark)
Temperature change (°C)	-14.5	**- 13.5**	**- 16** (previous box and this box crrect = 1 mark)

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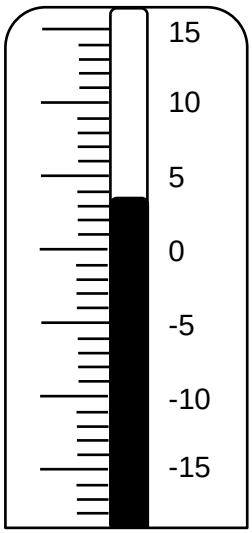
The final temperature reading of group C is shown on the thermometer to the right.



(a) Complete the tables on the previous page, by reading the final result for group C and recording it in the correct table. Then fill in any other values that are missing, by calculating the change in temperature (i.e. final – initial). (2 marks)

The following diagrams represent the energy changes that can occur during a reaction, as well as illustrate whether a reaction is endothermic or exothermic.

Diagram X

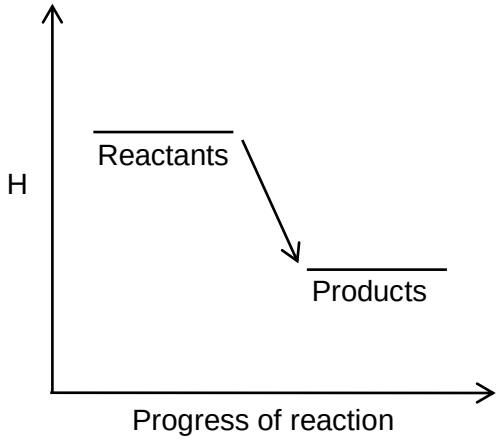
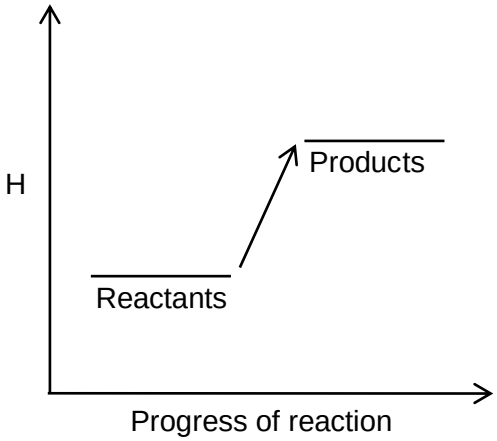


Diagram Y



Choose **one** of the reactions investigated (A, B or C) that corresponds to Diagram X.

(b) State the reaction (A, B or C) and explain what information this diagram provides in terms of the bond breaking and bond making that has occurred in your chosen reaction. (3 marks)

I chose reaction **A** or **B** or **C** *(circle your choice of reaction)*

B, (*because the temperature of the reaction increased),* **This corresponds to Diagram X which represents an exothermic reaction. (1)**

This means that the energy required to break the bonds (in the reactants) was less (1) than the energy released when the new bonds (between the products) formed (1)

Many students answered this question by giving information about the enthalpy contained in the reactants and products, rather than in terms of the energy required for bond BREAKING or energy released in bond FORMING.

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Choose **one** of the reactions investigated (A, B or C) that corresponds to Diagram Y.

(c) State the reaction (A, B or C) and explain why this diagram represents your chosen reaction. Include a description of how the Law of Conservation of Energy relates to this diagram. (4 marks)

- **A or C, because the temperature decreased**
- **Diagram Y is an endothermic reaction, showing that heat has been taken in from the surroundings**
- **This heat has been converted to enthalpy, so the enthalpy of P > R**
- **This upholds the Law of Conservation of Energy because energy has not been created or destroyed, only converted from one form to another (heat to enthalpy)**

(d) Explain why the groups would have chosen to carry out three trials. (2 marks)

- **so they could calculate an average**
- **minimise the effects of random error**
- **greater reliability of data / results**

… any 2 correct statements

(e) Which group had the most **precise** results? Justify your answer and explain the difference between precise and accurate. (3 marks)

- **Group A has the most precise**
- **They had the smallest range in their results**
- **Precise values are close together, accurate values are close to the actual / theoretically correct value**

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Group B realised that they had forgotten to 'tare' (reset to zero) the balance they used to weigh out the magnesium metal. This resulted in them using **less** Mg(s) than intended in each trial.

(f) Is this a random or systematic error? Justify your choice **and** state the likely effect that this error would have had on the final temperatures that group B measured (i.e. higher, lower or unchanged)? (3 marks)

- **Systematic**

  Justify your choice

- **this type of error can be minimised by using correct scientific technique (i.e. taring the balance) / this type of error causes consistently high or low measurements to be made (i.e. affects all measurements similarly)**

  state the likely effect that this error would have had on the final temperatures

- **final temp measured would likely be lower than if more Mg had been used (as this is an exothermic reaction, you could assume a larger amount of Mg would have allowed the reaction to proceed further and therefore produce more heat)**

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Question 33 **(19 marks)**

Diesel is a fuel that can be obtained from crude oil. It is used in most forms of transport, from trucks, cars and tractors to aircraft and rail cars. Biodiesel is most commonly produced from vegetable oil in a chemical reaction called transesterification. It can be used in pure form, in many of the same vehicles as regular diesel, however it is often used as a biodiesel-diesel mix.

(a) Briefly describe two (2) advantages of using biofuels instead of fossil fuels as an energy source. (2 marks)

use renewable resources rather than non-renewable, lower overall CO_2 emissions, decreased environmental impact such as global warming

- **polar ice caps melting**
- **ocean acidification,**
- **more sustainable process… any 2 relevant points (p. 107 Lucarelli)**

(b) State two (2) reasons it is not always possible for people to use biofuels. (2 marks)

- **not available to lots of people / countries / places in the world,**
- **expensive, new technology**
- **processes not developed properly yet,**
- **not available on large enough scale for general public… any 2 relevant points**

The table below gives some information regarding diesel and biodiesel.

	Formula	Molecular mass (M)	Energy output (MJ kg^{-1})
Diesel	$C_{18}H_{34}$	**250.452**	44.98
Biodiesel	$C_{18}H_{36}O_2$	**284.468**	38.48

(c) Complete the table by calculating the molecular mass (M) of each fuel. (2 marks)

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(d) Calculate the energy output of **diesel** in kilojoules per mole (kJ mol^{-1}).
Note: 1 MJ = 1 x 10^6 J. (4 marks)

Diesel energy output of 44.98 MJ kg^{-1} (from table on the previous page);

Output = ($\frac{g}{mol} \rightarrow \frac{kg}{mol}$) x ($\frac{MJ}{kg} \rightarrow \frac{kJ}{kg}$)

Output = $\frac{250.452 \div 1000\ kg}{1\ mol}\ X\ \frac{44.98\ X\ 1000\ MJ}{1\ kg} = \mathbf{11265.33\ \frac{kJ}{mol}\ (Diesel)}$

OR stepwise, **44.98 MJ** = **44.98 x 10^3 kJ**

1 kg = **1000 g**

n(diesel in 1 kg) = **mass x M_r**

= **1000** g **/ 250.452** g/mol

= **3.99278** mol

energy output in kJ / mol = **44.98 x 10^3** kg **/ 3.99278** mol

= **11 265.33 kJ mol^{-1}**

~ **11 300 kJ mol^{-1} (3sf)**

The equation for the combustion of **biodiesel** is shown below.

$$C_{18}H_{36}O_2(l) + 26\ O_2(g) \rightarrow 18\ CO_2(g) + 18\ H_2O(l) + \mathbf{10946\ kJ}$$

If a sample of biodiesel was combusted and 7.045 tonnes **(4SF)** of $CO_2(g)$ was released into the atmosphere;

(e) Calculate the mass of biodiesel that would have been consumed. Express your answer to the appropriate number of significant figures. (5 marks)

m(CO_2) = 7.045 tonnes **(4SF)** = **7.045 x 10^6 g**

n(CO_2) = **m/M(CO_2)**

= **7.045 x 10^6** g **/ 44.01** g/mol

= **160077.255 mol**

n(biodiesel, $C_{18}H_{36}O_2$) = $\frac{1}{18}$ x n(CO_2)

$\frac{1}{18}$ *is from the Stoichiometry in the reaction quation above*

= **$\frac{1}{18}$ x 160077.255**

= **8893.1808 mol**

m(biodiesel) = **nM($C_{18}H_{36}O_2$)**

= **8893.1808 x 284.468**

= 2 529 825 g

= **2.530 t OR 2.530 x 10^6 g (4SF)**

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(f) Calculate the amount of energy released. (2 marks)

energy released = $\frac{1}{18}$ x n(CO_2) x 10946 kJ

= $\frac{160077.255}{18}$ x 10946 kJ

Style of answers accepted = 97 344 757 kJ OR 97 300 000 kJ

= 97 344 MJ OR 9.734 x 10^7 kJ

~ 97 300 MJ OR 9.73 x 10^7 kJ (3sf)

OR

energy released = n(biodiesel) x 10946 kJ

= 8893.1808 mol x 10946 kJ

Style of answers accepted = 97 344 757 kJ OR 97 300 000 kJ

= 97 344 MJ OR 9.734 x 10^7 kJ

~ 97 300 MJ OR 9.730 x 10^7 kJ (3sf)

(g) What mass of **diesel** would have been needed to release this same amount of energy? (2 marks)

Using original energy output of diesel 44.98 MJ kg^{-1} to compare

Energy = output x mass

= 44.98 x mass

So, rearrange to get, mass = $\frac{energy}{output}$

mass = $\frac{97344}{44.98}$ = 2164.16185 kg = 2.16 tonnes

97 344 MJ / 44.98 MJ kg^{-1}

= 2164 kg diesel required

= 2.164 t ~ 2.160 t (3sf)

OR

Comparing kJ mol^{-1} values;

Biodiesel / diesel = 97 344 757 kJ / 11 265 kJ mol^{-1}

= 8641.35 moles

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m(diesel required, $C_{18}H_{34}$) = nM($C_{18}H_{34}$)

= n x (18 x 12.01 + 34 x 1.008)

= 8641.35 x 250.452

= 2 164 242 g

= 2.164 t diesel required ~ 2.160 t diesel required (3sf)

(So it works out that less diesel (2.164 t) is used to put out the same energy output as the biodiesel 2.530 t)

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Question 34 **(9 marks)**

Hydrazine (N_2H_4) is a toxic, unstable substance, which is sometimes used in rocket fuels. When hydrazine is passed over a catalyst such as molybdenum nitride on alumina, it decomposes very quickly according to the following equation;

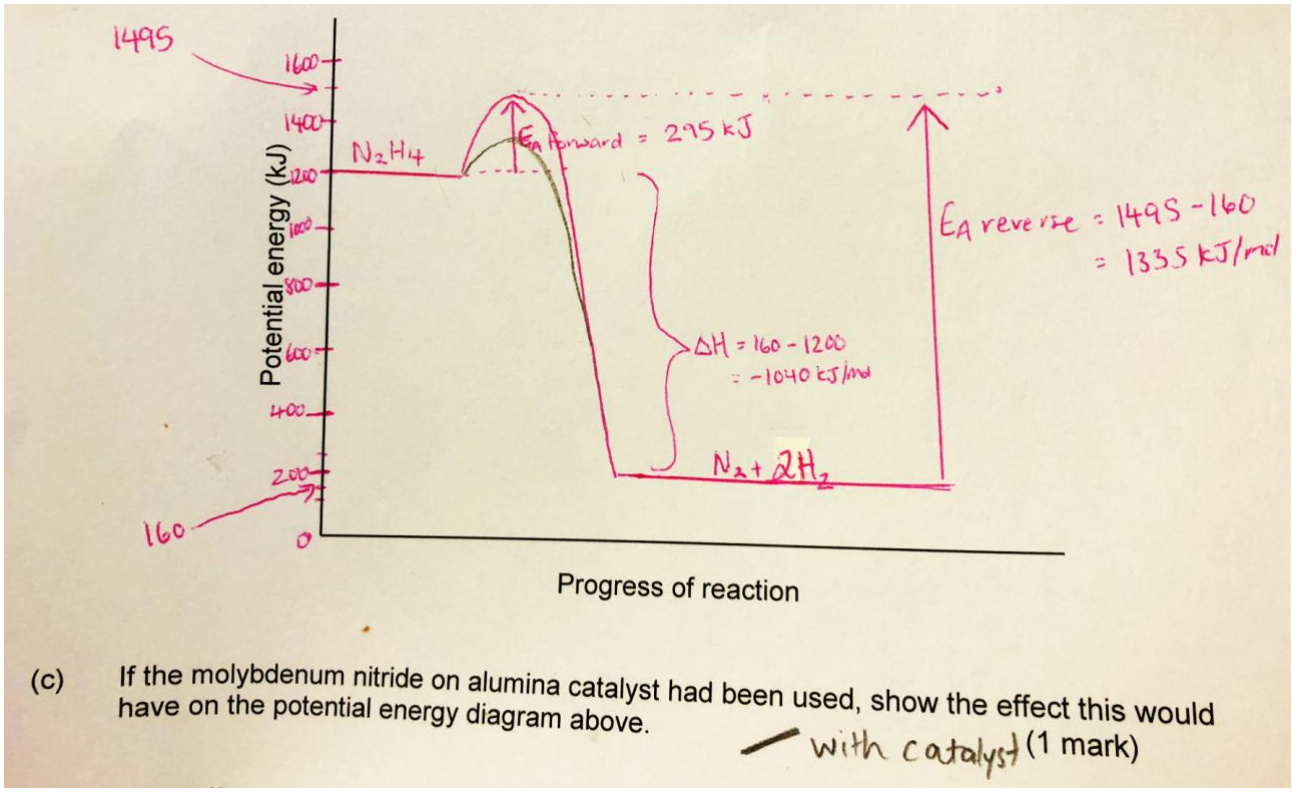
$$N_2H_4\ (l) \rightarrow N_2\ (g) + 2\ H_2\ (g)$$

The activation energy for this reaction is 295 kJ mol^{-1} and the activation energy for the reverse reaction is 1335 kJ mol^{-1}.

(a) Calculate the enthalpy change (ΔH). (1 mark)

$\Delta H = H_p - H_R = 160-1200 = -$ 1040 kJ mol^{-1}

(b) Sketch a labelled potential energy diagram for the uncatalysed decomposition of hydrazine. Label the activation energy(1), reverse activation energy(1) and enthalpy change(1) (make sure the relative scale of your diagram is reasonable (1)) (4 marks)



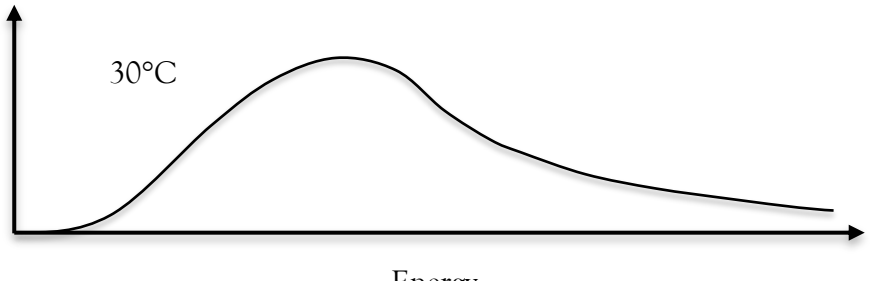
(d) What effect (higher, lower, unchanged) would the addition of a catalyst have on the value of each of the following? (3 marks)

(i) Activation energy **Lower**

(ii) Reverse activation energy **Lower**

(iii) Enthalpy change **unchanged**

(c) The graph below shows the distribution of molecular energies in the reaction vessel at 30°C. ON THESE AXES, **sketch a graph to show** how the distribution would change if the temperature were raised to some new temperature T_2. (1 mark)



(d) Explain why reaction rate increases with increasing temperature. Refer to collision theory in your answer. (3 marks)

(From Lucarelli, p. 117)

At higher temperature, the reactant particles (Hydrazine (N_2H_4)) **on average have greater kinetic energy (1),**

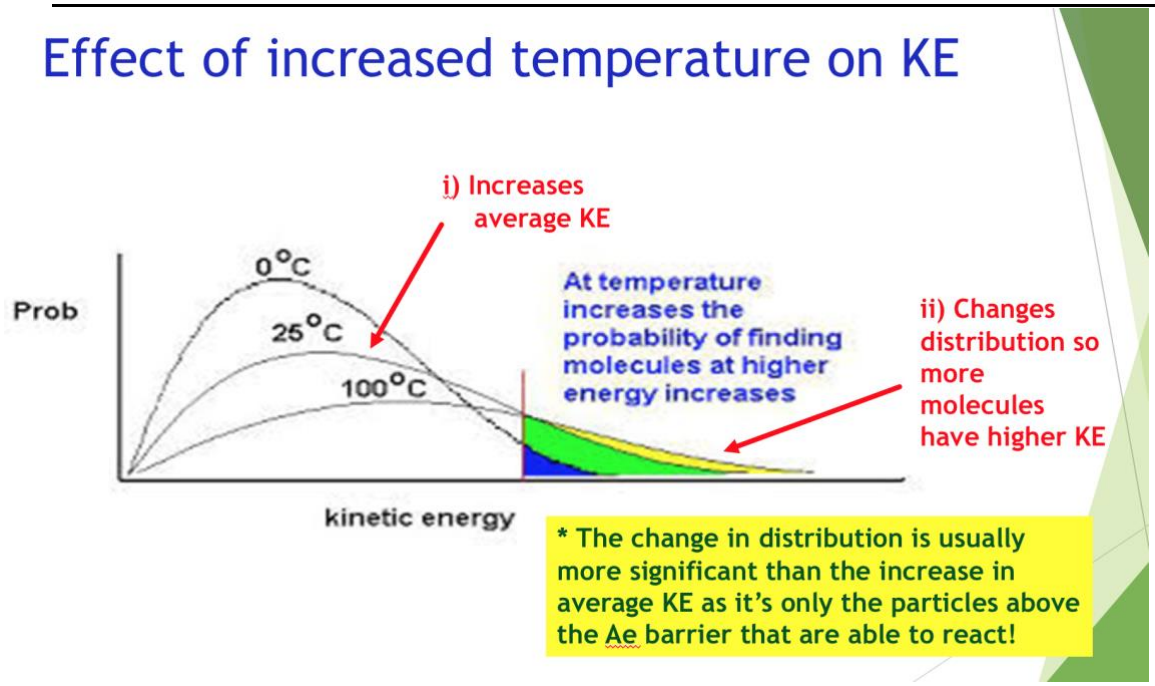
This means a higher percentage of collisions have energy greater than the activation energy. (1)

Thus a greater percentage of the collisions are successful, per unit time or discuss the "frequency" of the successful collisions. (1),

Hence the reaction rate increases.

End of questions.

More detailed info in the next page.



Effect of higher average kinetic energy

- The higher average kinetic energy means particles are moving faster.
- The faster they move, the greater the chance of collisions.
- The greater number of collisions means there is a greater chance of a successful collision and hence a higher reaction rate.

Effect of change in distribution of the kinetic energies.

More particles have higher kinetic energies, therefore, when collisions do occur, more particles will have sufficient energy to overcome the activation barrier, and hence more collisions will be successful and therefore the reaction rate will increase.

This has a large effect on reaction rate. (more than the increase in average KE)

- As even if the average KE increases, if it isn't above the activation energy barrier, then the collision isn't going to be successful.

Spare answer page

Question number: _____

Spare answer page

Question number: _____

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Question number: _____

Acknowledgements

Question 11 *Source: http://scienceaid.co.uk/chemistry/fundamental/particles.html*

Question 36 *Source: OpenStax, Physics - grade 10 [caps 2011]. OpenStax CNX. Jun 14, 2011 Download for free at http://cnx.org/content/col11298/1.3*