CHEMISTRY UNIT 1

Semester One Examination 2017

Question/Answer Booklet

Student Name: _____

Teacher's Name: _____

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	Number of questions available	Number of questions to be answered	Suggested working time (minutes)	Marks available	Percentage of exam
Section One: Multiple-choice	20	20	40	/40	/25
Section Two: Short answer	10	10	50	55	/35
Section Three: Extended answer	4	4	60	/65	/40
					/100

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 questions 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   **25%   (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: 40 minutes.

___

1.   An $^{56}Fe^{2+}$ ion contains:

   (a)   56 electrons, 56 protons and 26 neutrons.
   (b)   26 electrons, 26 protons and 30 neutrons.
   (c)   24 electrons, 26 protons and 30 neutrons.
   (d)   24 electrons, 30 protons and 26 neutrons.

2.   Substance X is a solid that melts at 1520 $^{\circ}C$. The substance X conducts electricity in both the solid and liquid states.

   Which of the following is most likely to be the structure/property of X?

   (a)   Metallic
   (b)   Ionic
   (c)   Covalent molecular
   (d)   Group 17 element

3.   The following three-dimensional structure can be used to explain which one of the following species?
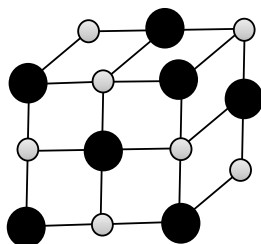
   (a)   MgO
   (b)   Diamond
   (c) $Cu(NO_3)_2$
   (d)   Na

4.   Which of the following elements has only three valence electrons?

   (a)   Lithium
   (b)   Boron
   (c)   Nitrogen
   (d)   Neon

5. Which of the following pairs of compound names and formulae are correct?

I	Methane	CH_4
II	Hydrogen peroxide	H_2O_2
III	Sulfuric acid	$HC\ell$
IV	Zinc hydroxide	$Zn(OH)_2$

    (a) I and II only.
    (b) II, III and IV only.
    (c) I, II and IV only.
    (d) I, II, III and IV.

6. Metals are able to conduct electricity because:

    (a) The positive metal ions pass charges to each other.
    (b) All electrons and the positive metal ions flow around freely.
    (c) The valence electrons flow around the metal ions.
    (d) All ions are freely moving.

7. Which of the following elements has the highest electronegativity?

    (a) O
    (b) Li
    (c) K
    (d) S

8. The decrease in atomic radii across a period in the periodic table is due to the increase in the number of:

    (a) neutrons
    (b) electrons
    (c) protons
    (d) shells

9. Element X is likely to form X^{2+} ion in chemical reactions. This element forms its only chloride by heating X with chlorine gas.

    What is the equation for the formation of the chloride of X?

    (a) $2X + C\ell_2 \rightarrow 2XC\ell$
    (b) $X + C\ell_2 \rightarrow XC\ell_2$
    (c) $X + 2C\ell_2 \rightarrow XC\ell_4$
    (d) $X + 3C\ell_2 \rightarrow XC\ell_6$

SEE NEXT PAGE

10. Select the most appropriate explanation for why an ionic substance can conduct electricity in aqueous solution but not in the solid state.

    (a)   In the solid state, the positive and negative ions are fixed within a 3D crystallised lattice that requires a large amount of energy to overcome.
    (b)   In the solid state, the positive ions and delocalised electrons are in a fixed 3D lattice and cannot move.
    (c)   In the aqueous solution, the delocalised electrons are no longer in a fixed 3D lattice and are free to move and conduct electricity.
    (d)   In the aqueous solution, the positive and negative ions are no longer in a fixed 3D lattice and are free to move and conduct electricity.

11. Use the information in the diagram below to calculate ΔH for the reaction.
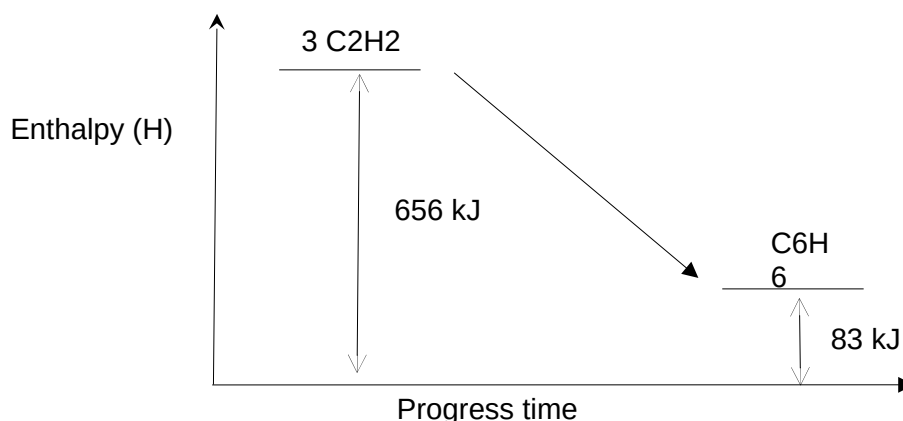
    (a)   + 739 kJ
    (b)   + 573 kJ
    (c)   – 573 kJ
    (d)   – 656 kJ

12. Which statement about change in enthalpy is true?

    (a)   Heat is given off to the surroundings in endothermic reactions.
    (b)   Enthalpy is a chemical substance of heat.
    (c)   Enthalpy is associated with kinetic energy of the reactants.
    (d)   The sign of ΔH is always positive in endothermic reactions.

13. Combustion of any fuel, by its very nature, is always exothermic. This is because:

    (a)   the chemical reaction involves the breaking of existing bonds to release energy to the surroundings.
    (b)   the chemical reaction absorbs heat from the surroundings.
    (c)   the enthalpy of the products is less than the enthalpy of the reactants.
    (d)   None of the above.

SEE NEXT PAGE

14. When 3.00 moles of zinc metal reacts with excess hydrochloric acid (HCℓ), how many moles of hydrogen gas is expected to be produced?

    (a) 1.50 moles
    (b) 2.00 moles
    (c) 3.00 moles
    (d) 4.50 moles

15. The percentage composition (percentage by mass) of aluminum in aluminum (III) hydroxide is:

    (a) 61%
    (b) 44%
    (c) 35%
    (d) 12%

16. For the following **unbalanced** chemical equation:

    __ Fe + __ Cℓ_2 → __ FeCℓ_3

    What coefficients would balance the equation?

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

17. The formula of hydrated sodium sulfate is $Na_2SO_4 \cdot 10H_2O$. The total number of atoms in one formula unit of this compound is:

    (a) 7
    (b) 17
    (c) 27
    (d) 37

18. In two moles of nitrogen monoxide (NO) molecules, there are a total of approximately:

    (a) 3.0×10^{23} nitrogen atoms.
    (b) 6.0×10^{23} nitrogen atoms.
    (c) 1.2×10^{24} nitrogen atoms.
    (d) 1.8×10^{24} nitrogen atoms.

19. For the following hydrocarbon (C_8H_{18}), how many alkyl groups are there?

$$CH_3 \qquad CH_3$$
$$| \qquad\quad |$$
$$CH_3 - CH - CH_2 - C - CH_3$$
$$|$$
$$CH_3$$
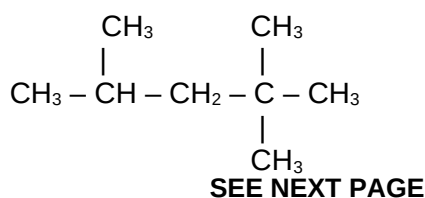
SEE NEXT PAGE

    (a)   2
    (b)   3
    (c)   4
    (d)   5

20. C_6H_{12} is the chemical formula of a/an:

    (a)   Cycloalkene.
    (b)   Benzene.
    (c)   Alkane.
    (d)   Alkene.

End of Section One

Section Two: Short answer **35% (55 marks)**

This section has **ten (10)** 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.

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: 50 minutes.

Question 26 **(8 marks)**

Complete the following by giving the name or formula for the following:

Formula	Name
$CuNO_3$	
$CC\ell_4$	
$Mg_3(PO_4)_2$	
	Aluminium carbonate
	Dinitrogen trioxide
	Calcium Sulfite
	Iron (III) hydrogenphosphate
	Ammonium ion

Question 27 (4 marks)

Observe the table below:

Species	Protons	Neutrons	Electrons
A	6	6	6
B	6	8	6
C	6	7	10
D	11	12	10
E	12	12	10
F	8	8	10

Using the table above by writing correct letters into the appropriate boxes below.

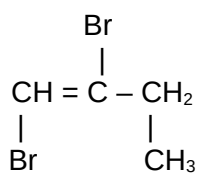|			
Isotopes		**Neutral atoms**	
Anions		**Cations**	

Question 28 (3 marks)

Complete the table by drawing or naming the following hydrocarbons using IUPAC nomenclature.

Structure	IUPAC Name
Cℓ H Cℓ | | | H – C – C – C – H | | | H H H	
	1-bromo-2-methylbenzene

SEE NEXT PAGE

$$
\begin{array}{c}
\text{Br} \\
| \\
\text{CH} = \text{C} - \text{CH}_2 \\
|\qquad\quad| \\
\text{Br}\qquad\text{CH}_3
\end{array}
$$

Question 29 **(4 marks)**

Consider the following reaction complete the table:

Excess bromine gas reacts with ethene gas.

Observation	
Balanced chemical equation with structural formula **(show all atoms)**	
Name of organic product	

Question 30   **(4 marks)**

On the axes below, sketch an energy profile diagram for the following reaction. Clearly label the reactants, products, axes, and ΔH. Includes all values.

$$H_{2\ (g)} + Cl_{2\ (g)} \rightarrow 2HCl_{\ (g)} \qquad \Delta H = -185 \text{ kJ mol}^{-1}$$
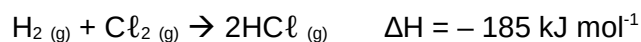
Question 31   **(9 marks)**

Write balanced **FULL** equations for the following reactions described below. Include the states of matter for all the species. For example, solid copper (II) sulfate as $CuSO_{4\ (s)}$.

(a)   Silver nitrate solution is mixed with iron (II) chloride solution to produce solid silver chloride and iron (II) nitrate solution.   (2 marks)

(b)   Solid Aluminium carbonate and a solution of nitric acid react to form a solution of aluminium nitrate, carbon dioxide and water.   (2 marks)

(c) Carbon dioxide gas is bubbled into limewater ($Ca(OH)_2$) to produce calcium carbonate precipitate and a second product. (2 marks)

_____

(d) A dilute solution of ethanoic acid reacts with a solution of magnesium hydroxide to form a solution of magnesium ethanoate and water. (2 marks)

_____

States of matter for of all species (1 mark)

Question 32 **(6 marks)**

Beryllium, Magnesium and Calcium are metals in group 2 of the periodic table. Answer the following questions with explanation using the atomic structure of these elements.

(a) Explain why these metals are malleable. (2 marks)

_____

_____

_____

_____

(b) Describe and explain the trend in first ionisation energy for Beryllium, Magnesium and Calcium. (4 marks)

_____

_____

_____

_____

_____

_____

_____

_____

SEE NEXT PAGE

Question 33 **(4 marks)**

Carbon dioxide is a colourless gas which occupies 0.04% of our atmosphere. The melting point and the boiling point of carbon dioxide are $-56.6 \, ^{\circ}C$ and $-78.5 \, ^{\circ}C$ respectively.

Explain why carbon dioxide has a very low melting and boiling point.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Question 34 **(6 marks)**

Complete the following table.

Species	Bonding present (Covalent moleculer, covalent network, ionic and/or metallic)	Electrical conductivity at room temperature (Yes or no)
Gold		
Diamond		
SiO_2		
NO_2		
Marble ($CaCO_3$)		
$AgNO_3$ Solution		

Question 35 **(7 marks)**

SEE NEXT PAGE

The average human requires 120 grams of glucose ($C_6H_{12}O_6$) per day.

(a)   Calculate the percentage by mass of carbon in each glucose molecule.   (3 marks)

_____

_____

_____

_____
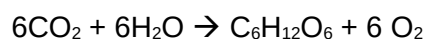
(b)   How many grams of CO_2 (in the photosynthesis reaction) are required for this amount of glucose? The photosynthetic reaction is:

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2$$

(4 marks)

_____

_____

_____

_____

_____

End of Section Two

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

SEE NEXT PAGE

This section contains **four (4)** 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: 60 minutes.

Question 36 (13 marks)

The following simplified diagram shows the path of a $^{20}Ne^+$ ion through a mass spectrometer.
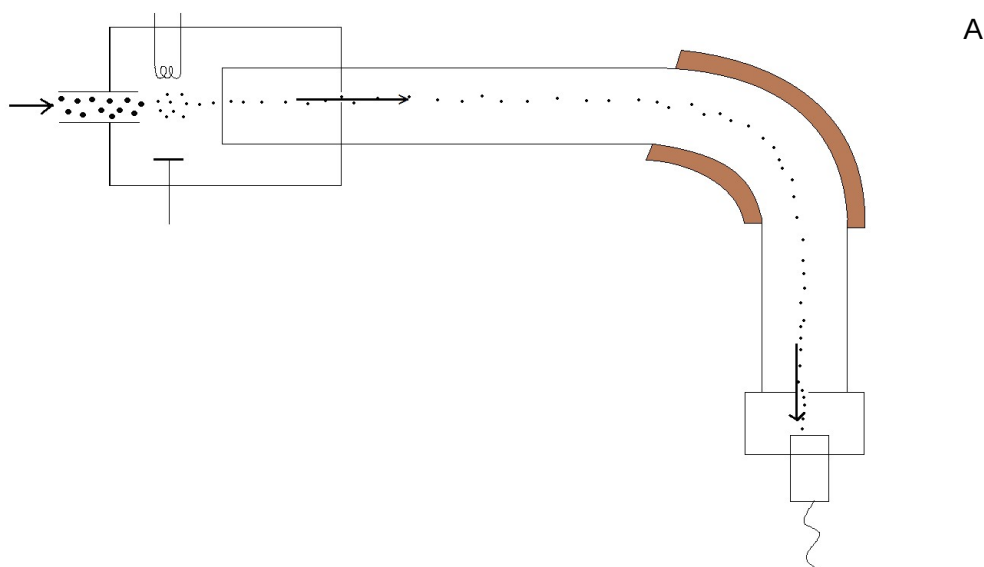
(a)
    i)   What is the name of part A in this mass spectrometer? (1 mark)

    ii)   Why is part A required in this mass spectrometer? (1 mark)

Continue Question 36

(b)

SEE NEXT PAGE

i) On the diagram of the mass spectrometer, sketch the path that would be taken by a $^{21}Ne^+$ ion introduced if it were into the spectrometer at the same time as the $^{20}Ne^+$ ion shown. (1 mark)

ii) Explain why the paths travelled by the two ions differ. (2 marks)

_____

_____

_____

The relative abundances of all the neon isotopes in a sample is collected using the mass spectrometer. The result is shown below. Note that m/z value is equivalent to the mass number of a neon ion. (For example, m/z = 20 means $^{20}Ne^+$ isotope.)

Neon isotopes: intensity VS m/z chart
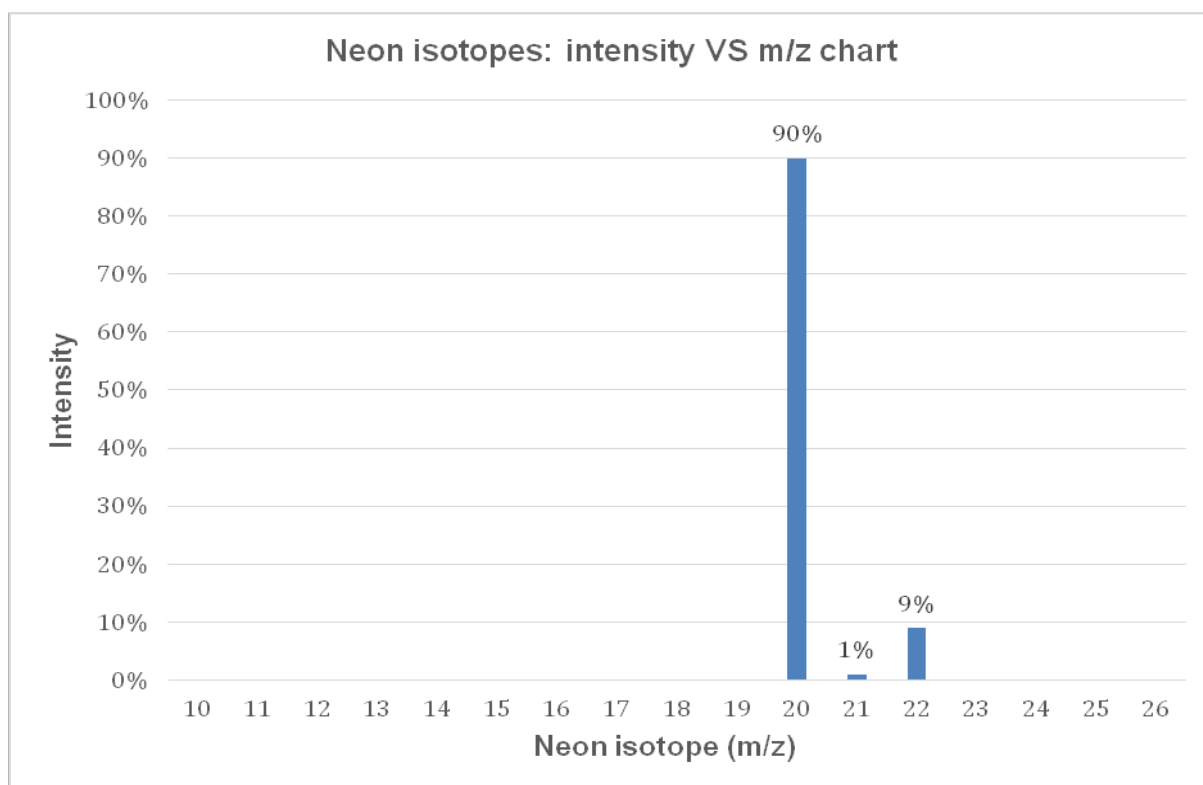
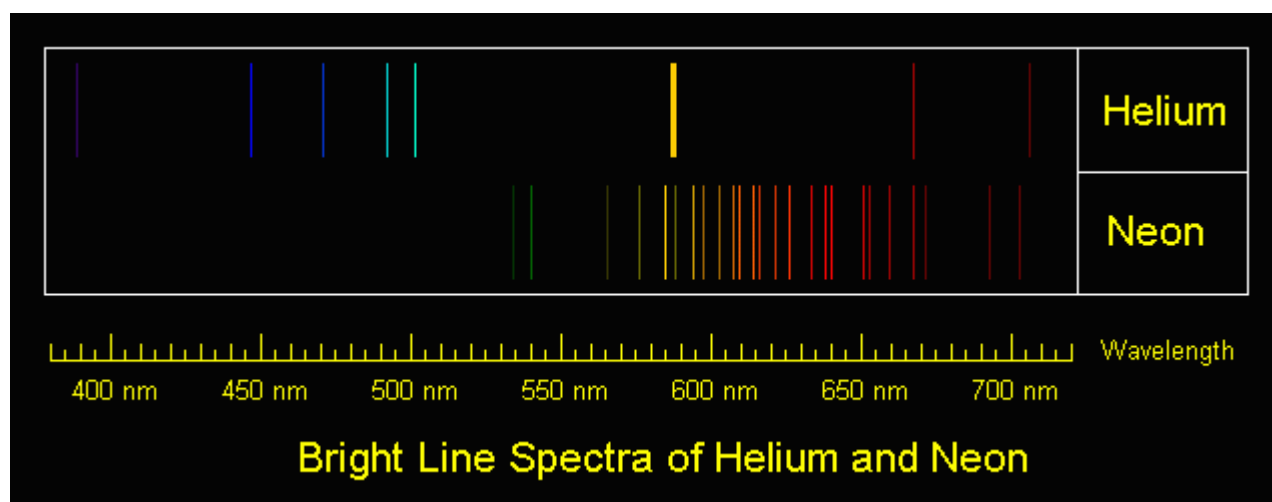(c) Use the above graph to calculate the relative atomic mass of neon. (2 marks)

_____

_____

_____

_____

Atomic absorption spectroscopy (AAS) can be used to distinguish different elements such as neon and helium atoms. The diagram below shows the emission spectra of helium and neon.

SEE NEXT PAGE

Bright Line Spectra of Helium and Neon

(d) Explain how these spectra lines are produced. (3 marks)

_____

_____

_____

_____

_____

_____

(e) The number of lines spectra of helium and neon are different. Give an explanation for this.
(3 marks)

_____

_____

_____

_____

_____

_____

Question 37 **(15 marks)**

The following table shows the radii of different elements.

SEE NEXT PAGE

Element	Atomic Number (Z)	Atomic radius (x10^{-12} metres)
O	8	66
F	9	68
Ne	10	67
Na	11	186
Mg	12	160
Al	13	143
Si	14	118
P	15	110
S	16	102
Cl	17	99
Ar	18	95

(a)   Graph these results below, by plotting the atomic number on the horizontal axis. If you make a mistake, a spare grid is available at the back of this booklet.   (4 marks)

(b)

    i)   From the graph, describe the trend in the atomic radius that occurs from sodium to argon.   (1 mark)

SEE NEXT PAGE

_____

_____

ii) Explain why this trend occurs.   (3 marks)

_____

_____

_____

_____

(c) Compare the radii of an oxygen atom and sulfur atom. Explain the difference.

(2 marks)

_____

_____

_____

_____

_____

(d) Would a chloride ion be bigger or smaller than the chlorine atom? Explain your answer.

(3 marks)

_____

_____

_____

_____

_____

(e) Describe the changes in electronegativity that would be observed from sodium to argon.

(2 marks)

_____

_____

_____

Question 38   **(16 marks)**

SEE NEXT PAGE
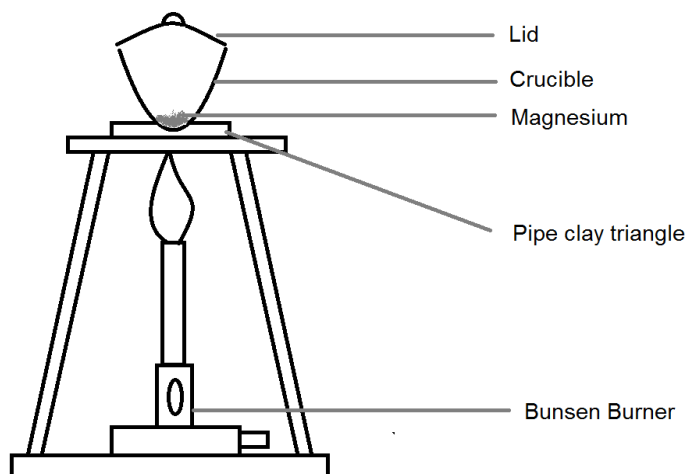
When magnesium metal reacts with oxygen from the air, a grey-white solid is formed. This chemical reaction can be performed in a crucible in the science lab.

(a)   Write a balanced chemical equation for this reaction.   (2 marks)

_____

The setup of the combustion reaction is shown below:

A student, Paul, wants to use this experiment to find the mass of oxygen reacting with the magnesium.

(b)   The teacher of the student, Mrs Philips, suggests that the lid of the crucible need to be open slightly during the reaction. Explain the reason for this.   (1 mark)

_____

_____

_____

After the experiment, Paul summarises his result as follows:

Mass of crucible and lid (g)	38.5980 g
Mass of crucible, lid and magnesium (g)	38.7860 g
Mass of crucible, lid and magnesium oxide (g)	38.8873 g

(c)   Use Paul's results to calculate:

                                                                                        (2 marks)

Mass of Magnesium (g)	
Mass of Magnesium oxide (g)	

(d)   Calculate the number of moles of magnesium at the beginning of the experiment.   (2 marks)

SEE NEXT PAGE

_____

_____

_____

_____

(e)   Calculate the number of moles of magnesium oxide produced at the conclusion of the
        experiment.   (2 marks)

_____

_____

_____

_____

(f)   Using your equation and answer from part (d), calculate the number of moles of magnesium
        oxide Paul is **expected** to produce in this experiment. Explain why the expected value is
        different to part (e).   (3 marks)

_____

_____

_____

_____

_____

_____

(g)   Use the answer from part (d), calculate the theoretical mass of the oxygen gas reacted in this
        combustion. How does this value compare to the amount which actually reacted?   (4 marks)

_____

_____

_____

_____

_____

SEE NEXT PAGE

Question 39 **(21 marks)**

A fuel is any material that can be made to react with oxygen gas so that it releases energy as heat. Fossil fuels are fuels from natural processes such as anaerobic decomposition of buried dead organisms. One example of a fossil fuel is ethane.

The **unbalanced** chemical equation of the combustion of ethane is shown below:

$$C_2H_6 \quad + \quad O_2 \quad \rightarrow \quad CO_2 \quad + \quad H_2O$$
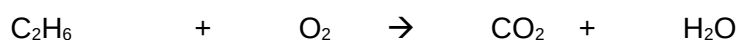
(a) Balance the chemical equation above using whole numbers. (1 mark)

(b) Draw dot diagram (Lewis structures) for C_2H_6. Show all valence shell electron pairs as either : or —. (2 marks)

For example, water   H : Ö : H   or   H—Ö—H   or   H—Ö—H

C_2H_6	

The following table shows how much heat energy is required to break each bond of all reactants and the total heat energy required for the reaction. This can be done by referring to the chemical equation in part (a).

Species	Bond within the molecule	Number of bonds in each molecule	Number of molecules from the equation	Energy required to break one bond (kJ/mol)	Energy required to break all bonds (kJ/mol)
C_2H_6	C – C (single bond)	1	2	347	1 x 2 x 347 = 694
	C – H (single bond)	6	2	410	6 x 2 x 410 = 4920
O_2	O = O (double bond)	1	7	494	1 x 7 x 494 = 3458
				Total energy required to break all bonds	9072

(c)   Use the method in previous page and equation in part (a) to complete the following table.

(4 marks)

Species	Bond within the molecule	Number of bonds in each molecule	Number of molecules from the equation	Energy released when forming one bond (kJ/mol)	Energy released when forming all bonds (kJ/mol)
CO_2	C = O (double bond)			799	
H_2O	H – O (single bond)			460	
				Total energy required to form for all bonds	

(d)   By considering the energy released when new bonds form and the energy required for breaking bonds. Calculate the net energy change. Determine if the reaction is an endothermic or exothermic reaction.

(2 marks)

(e)

SEE NEXT PAGE

    i)   Is the value of ΔH positive or negative? Explain your answer.   (2 marks)

_____

_____

_____

    ii)   Describe a consequence that occurs to the surroundings after this chemical reaction.
    (1 mark)

_____

_____

1.00 tonne of ethane gas is pumped into a combustion chamber to undergo this combustion reaction. Assume that there is no loss of energy in the reaction. (1 tonne = 1000 kg)

(f)   Calculate the number of moles of ethane reacted.   (2 marks)

_____

_____

_____

_____

(g)   Calculate the mass, in tonnes, of oxygen required in this reaction if the ethane is fully reacted.   (4 marks)

_____

_____

_____

_____

_____

_____

_____

SEE NEXT PAGE

Continue Question 39

(h)   Using the answers in parts (d) and (f), calculate the energy produced by combusting of 1.00 tonne of ethane.   (3 marks)

End of examination.

Spare answer page

Question number: _____

Spare answer page

Question number: _____

Spare answer page

Question number: _____

Spare answer page

Question number: _____

Spare answer page

Question number: _____

Spare graph