Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Friday 23 May 2014 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH01/01R

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P42990A

6/6/6/6/

P 4 2 9 9 0 A 0 1 2 8

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following diagrams represents the electrons in the ground state of a boron atom?

	1s	2s	$2p_x$	$2p_y$	$2p_z$
☒ **A**	↑↓	↑↓	↑		
☒ **B**	↑	↑↓	↑	↑	
☒ **C**	↑↓	↑	↑	↑	
☒ **D**	↑	↑	↑	↑	↑

(Total for Question 1 = 1 mark)

2 Which of the following species contains the same number of electrons as neutrons?

☒ **A** $^{11}_{5}B$

☒ **B** $^{23}_{11}Na^{+}$

☒ **C** $^{24}_{12}Mg^{2+}$

☒ **D** $^{19}_{9}F^{-}$

(Total for Question 2 = 1 mark)

3 The recommended limit for safe exposure to sulfur dioxide in the air is 0.000025 %. What is this concentration in parts per million, ppm?

☒ **A** 25

☒ **B** 0.25

☒ **C** 0.025

☒ **D** 0.0025

(Total for Question 3 = 1 mark)

4 For which of the following pairs of elements does the second have a **higher** 1st ionization energy than the first?

	First element	Second element
☒ **A**	Mg	Al
☒ **B**	N	O
☒ **C**	Ne	Na
☒ **D**	K	Na

(Total for Question 4 = 1 mark)

5 In which of the following series of elements is there an **increase** in the melting temperatures from left to right?

☒ **A** Na Mg Al

☒ **B** Li Na K

☒ **C** B C N

☒ **D** Si P S

(Total for Question 5 = 1 mark)

6 What is the number of **atoms** in 2.8 g of ethene, C_2H_4?

DATA

- The molar mass of C_2H_4 is 28 g mol^{-1}
- The Avogadro constant is 6.0×10^{23} mol^{-1}

☒ **A** 1.0×10^{22}

☒ **B** 6.0×10^{22}

☒ **C** 1.2×10^{23}

☒ **D** 3.6×10^{23}

(Total for Question 6 = 1 mark)

7 A compound has the following percentage composition by mass.

C 61.0% H 15.3% N 23.7%

The empirical formula of the compound is

☒ **A** CH_3N

☒ **B** C_3H_9N

☒ **C** $C_6H_9N_2$

☒ **D** $C_8H_2N_3$

(Total for Question 7 = 1 mark)

8 Carbon monoxide and oxygen react together as follows.

$$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$$

If all volumes of gas are measured at the same temperature and pressure, the volume of carbon dioxide produced after 50 cm^3 of carbon monoxide react with 25 cm^3 of oxygen is

☒ **A** 100 cm^3

☒ **B** 75 cm^3

☒ **C** 50 cm^3

☒ **D** 25 cm^3

(Total for Question 8 = 1 mark)

9 Potassium chlorate(V), $KClO_3$, decomposes on heating as follows.

$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

What is the maximum volume of oxygen, measured in dm^3 at room temperature and pressure, which could be obtained by heating 0.50 mol potassium chlorate(V)?

[Molar volume of a gas = 24 $dm^3\,mol^{-1}$ at room temperature and pressure.]

☒ **A** 8

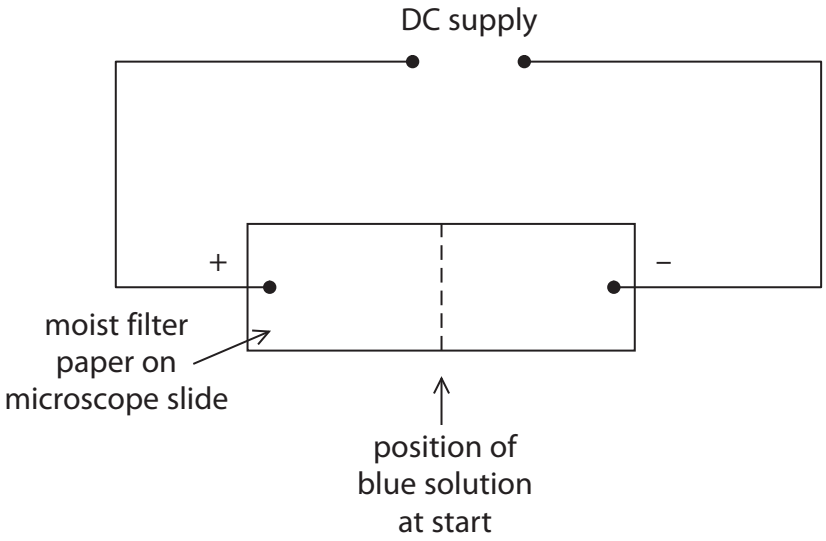
☒ **B** 18

☒ **C** 36

☒ **D** 72

(Total for Question 9 = 1 mark)

10 A spot of blue solution was placed in the centre of a piece of moist filter paper supported on a microscope slide and the following experiment was carried out.



After some time, a blue colour moved towards the negative terminal, but no change was visible in the region of the positive terminal. This is because

☒ **A** the negative ions in the solution were colourless and the positive ions were blue.

☒ **B** the positive ions in the solution were colourless and the negative ions were blue.

☒ **C** the negative ions in the solution had not moved but the positive ions had moved.

☒ **D** the positive ions in the solution had not moved but the negative ions had moved.

(Total for Question 10 = 1 mark)

11 The reaction for which the enthalpy change is the standard enthalpy change of formation of water, $\Delta H^{\ominus}_{f,298}$, is

☒ **A** $H_2(g) + ½O_2(g) \rightarrow H_2O(l)$

☒ **B** $H_2(g) + ½O_2(g) \rightarrow H_2O(g)$

☒ **C** $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

☒ **D** $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

(Total for Question 11 = 1 mark)

12 Which of the following molecules does **not** contain a double bond?

- ☒ **A** CO_2
- ☒ **B** C_2Cl_4
- ☒ **C** C_3F_8
- ☒ **D** $C_2H_2Cl_2$

(Total for Question 12 = 1 mark)

13 The bonding in lithium iodide has some covalent character because

- ☒ **A** the lithium ion polarizes the iodide ion.
- ☒ **B** the iodide ion polarizes the lithium ion.
- ☒ **C** there is a very large difference in electronegativity between lithium and iodine.
- ☒ **D** there is a very small difference in electronegativity between lithium and iodine.

(Total for Question 13 = 1 mark)

14 Which of the following data is **not** needed to calculate the lattice energy of sodium chloride when using a Born-Haber cycle?

- ☒ **A** Enthalpy change of formation of sodium chloride.
- ☒ **B** Enthalpy change of atomization of sodium.
- ☒ **C** First ionization energy of chlorine.
- ☒ **D** Electron affinity of chlorine.

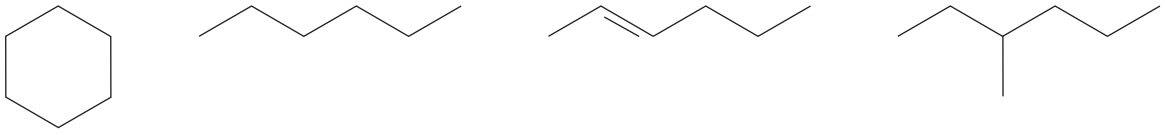
(Total for Question 14 = 1 mark)

15 The lattice energy of magnesium oxide is more negative than the lattice energy of magnesium fluoride because

- ☒ **A** oxide ions are larger than fluoride ions.
- ☒ **B** oxide ions are larger than magnesium ions.
- ☒ **C** oxide ions are more highly charged than fluoride ions.
- ☒ **D** there is only one oxide ion but two fluoride ions per magnesium ion.

(Total for Question 15 = 1 mark)

16 This question is about the organic compounds shown below.



W X Y Z

(a) The compounds which are isomers are

(1)

☒ **A** W and X

☒ **B** W and Y

☒ **C** W and Z

☒ **D** X and Z

(b) Which compound can react with chlorine to form $C_6H_{12}Cl_2$ as the **only** product?

(1)

☒ **A** Compound W

☒ **B** Compound X

☒ **C** Compound Y

☒ **D** Compound Z

(c) Which compound is reformed in the oil industry, producing one mole of a compound with formula C_6H_6 and four moles of hydrogen, H_2, only?

(1)

☒ **A** Compound W

☒ **B** Compound X

☒ **C** Compound Y

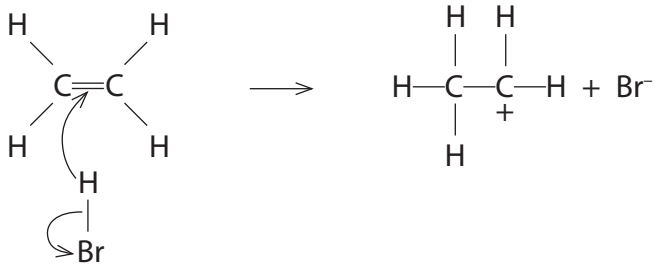
☒ **D** Compound Z

(Total for Question 16 = 3 marks)

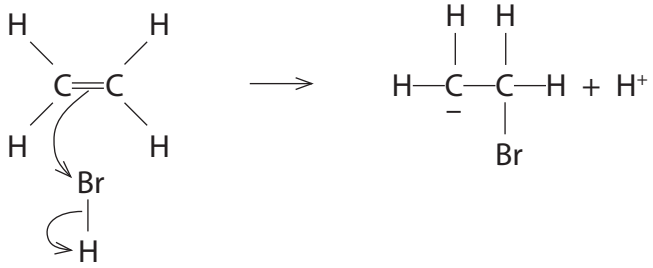
Use this space for any rough working. Anything you write in this space will gain no credit.

17 Which of the following equations shows the first step in the mechanism for the reaction between hydrogen bromide and ethene?

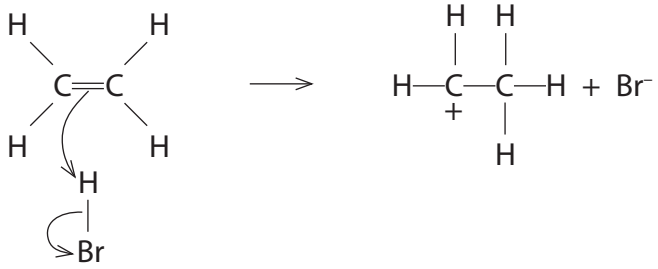
☒ **A**



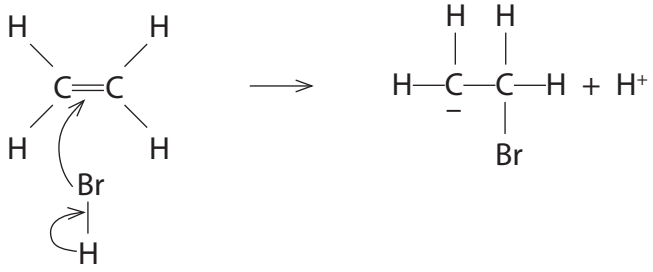
☒ **B**



☒ **C**



☒ **D**



(Total for Question 17 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

18 Scientists are developing sources of energy as alternatives to fuels produced from crude oil. Which of the following reasons for doing this is **incorrect**?

☒ **A** Crude oil is being used up faster than it is being formed.

☒ **B** Burning hydrocarbons affects global carbon dioxide levels.

☒ **C** Hydrocarbons from crude oil are a source of essential chemicals other than fuels.

☒ **D** Carbon dioxide produced by burning hydrocarbons is toxic to plants.

(Total for Question 18 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

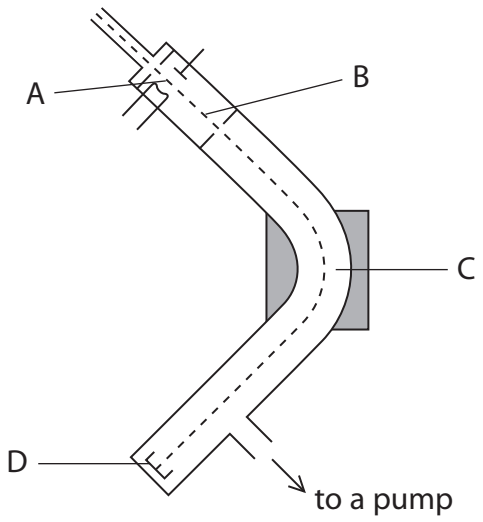
SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

19 Naturally occurring samples of potassium contain three isotopes, ^{39}K, ^{40}K and ^{41}K.

(a) The isotopes can be separated in a mass spectrometer.

(i) In the diagram below, particles are ionized at A and detected at D.



Name the **processes** occurring in the mass spectrometer at B and C.

(2)

B .....

C .....

(ii) A sample of potassium has the following composition.

Isotope	^{39}K	^{40}K	^{41}K
% abundance	93.22	0.12	6.66

Calculate the relative atomic mass of this sample of potassium, giving your answer to **two** decimal places.

(2)

(iii) Complete the table below to show the numbers of sub-atomic particles in an atom of each of the isotopes ^{39}K and ^{41}K.

(1)

Isotope	Electrons	Protons	Neutrons
^{39}K			
^{41}K			

(iv) Complete the electronic configuration for an atom of ^{39}K.

(1)

$1s^2$ .....

(v) Why is potassium placed after argon in the Periodic Table, even though it has a smaller relative atomic mass?

(1)

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*(vi) Explain why a potassium ion is smaller than a potassium atom.

(2)

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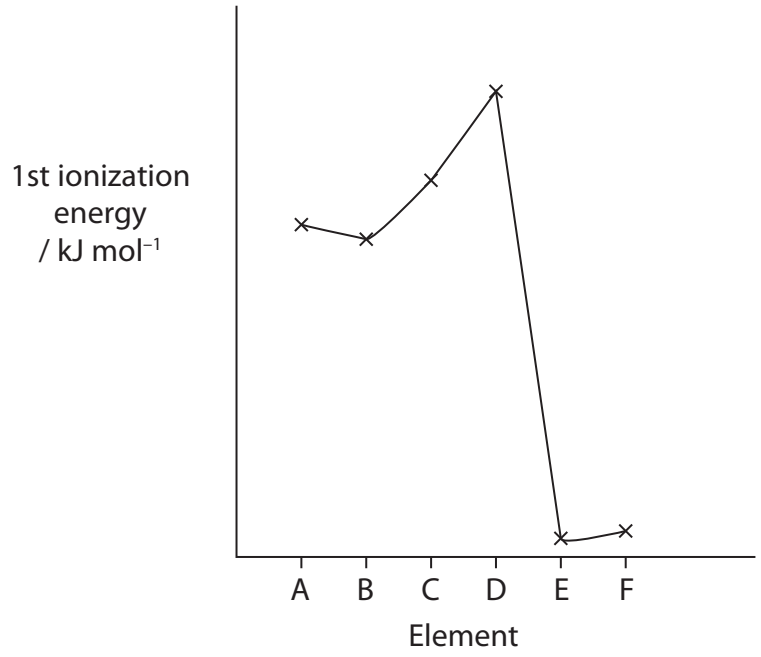
(b) The type of bonding in potassium is metallic.

Draw a labelled diagram to illustrate the metallic bonding in potassium.

(2)

(c) The graph shows the variation of first ionization energy with atomic number for six successive elements in the Periodic Table, including potassium. The letters used to label the elements are not their symbols.



(i) Define the term **first ionization energy**.

(3)

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(ii) Identify, with a reason, which element is potassium.

(2)

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(Total for Question 19 = 16 marks)

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20 In an experiment to make crystals of hydrated copper(II) nitrate, a sample of 5.60 g of copper(II) oxide was added to 50 cm^3 of 2.50 mol dm^{-3} nitric acid. The following reaction occurred.

$$CuO(s) + 2HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + H_2O(l)$$

(a) Calculate the number of moles of each reactant present, and use this to show that the copper(II) oxide was in excess.

The molar mass of copper(II) oxide, CuO, is 79.5 g mol^{-1}.

(3)

Moles of copper(II) oxide added

Moles of nitric acid used

The copper(II) oxide is in excess because .....

.....

.....

.....

(b) The copper(II) nitrate solution was heated gently to concentrate it, and then left to crystallize. The mass of hydrated copper(II) nitrate crystals, $Cu(NO_3)_2.6H_2O$, obtained was 12.52 g.

Calculate the percentage yield.

The molar mass of $Cu(NO_3)_2.6H_2O$ is 295.6 g mol^{-1}.

(3)

(c) Give **one** reason why the percentage yield is less than 100%, even though the nitric acid was completely reacted.

(1)

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.....

*(d) (i) The nitrate ion, NO_3^-, contains both covalent and dative covalent bonds.

What is the difference between these types of bond?

(2)

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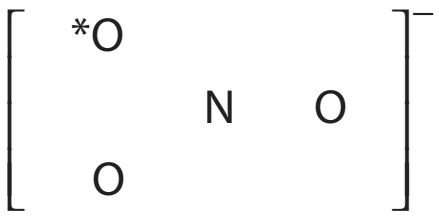
(ii) Complete the dot and cross diagram to show the bonding in the nitrate ion. Only the outer electron shells for each atom need to be shown.

Represent the nitrogen electrons with crosses (×), and oxygen electrons with dots, (•). The symbol * on the diagram represents the extra electron giving the ion its charge.

(3)



(Total for Question 20 = 12 marks)

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21 Propane is a saturated hydrocarbon with molecular formula C_3H_8.

*(a) Explain the meaning of the terms **saturated** and **hydrocarbon**.

(2)

Saturated .....

.....

Hydrocarbon .....

.....

(b) Propane is sold in small cylinders for use as a fuel in camping stoves. The enthalpy change of combustion of propane can be measured by experiment using one of these cylinders.

A known mass of propane is burned to heat a container of water, and the temperature rise of the water is measured.

The results of the experiment are shown below.

Mass of propane burned	0.33 g
Temperature of water at start	18.0 °C
Final temperature of water	45.1 °C
Mass of water in container	100 g

(i) How would the mass of propane which was burned be measured?

(1)

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.....

(ii) Calculate the energy transferred in the experiment, using the results above and the following expression.

Energy transferred (J) = mass × specific heat capacity × temperature change

The specific heat capacity of water is 4.18 J g^{-1} $°C^{-1}$.

(1)

(iii) Calculate the enthalpy change of combustion of propane, ΔH_c, in kJ mol^{-1}.

Give your answer to **three** significant figures and include a sign.

(3)

(iv) The results of this experiment are inaccurate due to heat loss.

Suggest **one** other source of error, other than measurement errors and limitations of the equipment.

(1)

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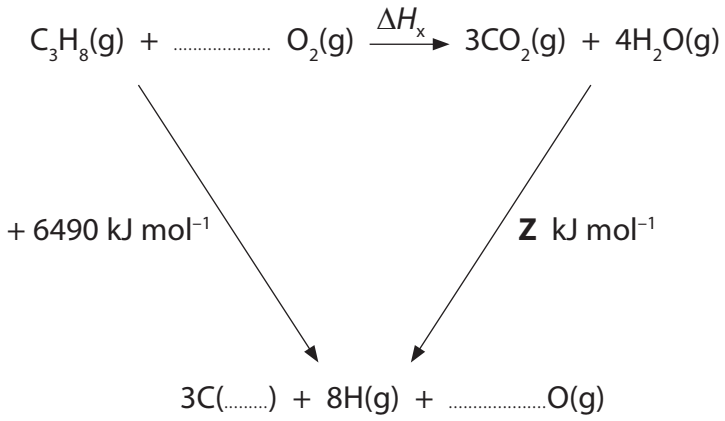
.....

(c) Another way of calculating the enthalpy change of combustion for propane is to use mean bond enthalpy data.

(i) Complete the equations in the Hess cycle below. The enthalpy change of +6490 kJ mol^{-1} is the total energy required to break the bonds in propane and in oxygen.

(1)



(ii) Use the data in the table to calculate the enthalpy change, **Z**, in kJ mol^{-1}.

Bond	Mean bond enthalpy / kJ mol^{-1}
C═O	805
H—O	464

(1)

(iii) Use the cycle in (c)(i), and your answer to (c)(ii), to calculate the enthalpy change, ΔH_x, in kJ mol^{-1}, for the combustion of propane.

(1)

(iv) The data book value for the standard enthalpy change of combustion, $\Delta H_c^{\ominus}$, for propane is –2219.2 kJ mol^{-1}. This value is more exothermic than that calculated using mean bond enthalpy data. Give **one** reason for this.

(1)

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.....

(Total for Question 21 = 12 marks)

22 When trichloromethane, $CHCl_3$, reacts with chlorine, the organic product is tetrachloromethane, CCl_4. The reaction proceeds by free radical substitution.

The equation for this reaction is

$$CHCl_3 + Cl_2 \rightarrow CCl_4 + HCl$$

(a) State the essential condition for this reaction to occur at room temperature.

(1)

.....

(b) The reaction mechanism involves free radicals. Explain what is meant by the term **free radical**.

(1)

.....

.....

(c) The reaction takes place in a series of steps.

(i) The initiation step is

$$Cl_2 \rightarrow 2Cl\bullet$$

Suggest why this initiation step is more likely than

$$CHCl_3 \rightarrow CCl_3\bullet + H\bullet$$

(1)

.....

.....

(ii) Write equations for the two propagation steps.

(2)

First propagation step

Second propagation step

(iii) Write an equation for the termination step in which tetrachloromethane is formed.

(1)

(d) Tetrachloromethane can be manufactured using the by-products of chlorination reactions.

$$C_2Cl_6 + Cl_2 \rightarrow 2CCl_4$$

Compare the atom economy of this process with that of the reaction which produces tetrachloromethane from trichloromethane and chlorine. A calculation is not required.

(1)

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(Total for Question 22 = 7 marks)

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23 This question is about isomers of C_4H_8.

(a) (i) Alkenes contain a carbon-carbon double bond, which consists of a σ bond and a π bond.

Show, and clearly label, the σ and π bonds on the diagram below.

(2)

C C

*(ii) Explain why the σ bond is stronger than the π bond.

(2)

(b) (i) Draw the structural formula of *E*-but-2-ene.

(1)

(ii) Explain why but-1-ene does not exhibit *E-Z* isomerism.

(1)

(iii) Describe the result of the test for the presence of a C═C bond in *E*-but-2-ene using bromine water. Give the displayed formula of the organic product.

(2)

Test result .....

.....

Displayed formula of organic product:

(c) Another test for C═C bonds is the reaction with acidified potassium manganate(VII).

Describe the result of this test using **but-1-ene** and give the displayed formula of the organic product.

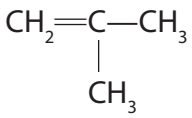
(2)

Test result .....

.....

Displayed formula of organic product:

(d) Another isomer of C_4H_8 has the structure shown below.



(i) Name this isomer.

(1)

.....

(ii) This isomer forms an addition polymer. Show the structure of this polymer by drawing **two** repeat units.

(1)

(e) 'Polybutene' is the name used by cosmetic companies for a mixture of poly(but-1-ene) and poly(but-2-ene).

An American "eco-cosmetics" company says that though 'polybutene' is considered a safe ingredient in lip gloss, it is non-sustainable to use it.

Suggest **one** reason to justify this statement.

(1)

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.....

(Total for Question 23 = 13 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)											(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series