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.*
- Show all the steps in any calculations and state the units.
- Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Information

- The total mark for this paper is 60.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Write your answers neatly and in good English.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

THE PERIODIC TABLE

Group

Period	1	2		3	4	5	6	7	0
1									4 **He** Helium 2
2	7 **Li** Lithium 3	9 **Be** Beryllium 4		11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
3	23 **Na** Sodium 11	24 **Mg** Magnesium 12		27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulfur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18

Transition metals (Period 4–6):

39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	63.5 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
86 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	99 **Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La** Lanthanum 57	179 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	210 **Po** Polonium 84	210 **At** Astatine 85	222 **Rn** Radon 86
223 **Fr** Francium 87	226 **Ra** Radium 88	227 **Ac** Actinium 89															

1
H
Hydrogen
1

Key

Relative atomic mass
Symbol
Name
Atomic number

Answer ALL questions.

1 Sodium sulfate is a compound with many uses.

(a) The formula of the main compound used as the source of sodium sulfate is $Na_2SO_4.10H_2O$

How many different elements are shown in this formula?

(1)

☒ **A** 2

☒ **B** 3

☒ **C** 4

☒ **D** 5

(b) Sodium sulfate can be made from sodium hydroxide and sulfuric acid.

Balance the equation for the reaction between sodium hydroxide and sulfuric acid.

(1)

..........................NaOH + ...H_2SO_4 → ....Na_2SO_4 + ...H_2O
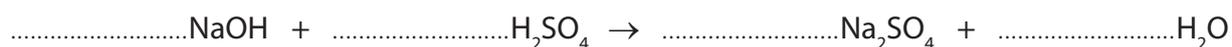
(c) Sodium hydroxide is manufactured by the electrolysis of brine in the diaphragm cell.

Sulfuric acid is manufactured using the contact process.

The table contains some statements about these two processes.

Place ticks (✓) in the boxes to show the two correct statements.

(2)

brine is a solution of sodium chloride in water	
the temperature used in the contact process is greater than 1000 °C	
an equation for the contact process is $SO_2 + H_2O \rightarrow H_2SO_4$	
the reactions in the diaphragm cell are displacement reactions	
the catalyst used in the contact process is vanadium(V) oxide	

(Total for Question 1 = 4 marks)

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2 The diagram shows the positions of some elements in part of the Periodic Table.

								He

Li		B		N		F	
	Mg		Si		S		Ar

(a) How many periods and groups are shown in this diagram?

(1)

	Periods	**Groups**
☒ **A**	2	4
☒ **B**	3	4
☒ **C**	2	8
☒ **D**	3	8

(b) How many elements shown in the diagram are noble gases?

(1)

☒ **A** 1

☒ **B** 2

☒ **C** 3

☒ **D** 4

(c) What is the formula of the compound formed between magnesium and fluorine?

(1)

☒ **A** MgF

☒ **B** Mg_2F

☒ **C** MgF_2

☒ **D** Mg_2F_2

(d) The table shows the percentage composition by mass of a sample of silicon.

Isotope	^{28}Si	^{29}Si	^{30}Si
Percentage (%)	92.2	4.70	3.10

Calculate the relative atomic mass of this sample of silicon.

Give your answer to one decimal place.

(2)

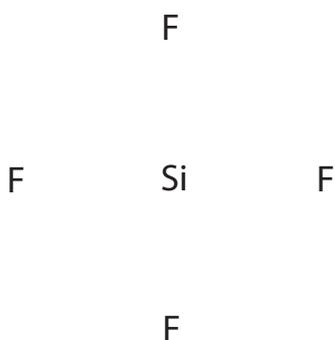relative atomic mass = ...

(e) A molecule of silicon tetrafluoride (SiF_4) contains covalent bonds.

Draw a dot and cross diagram to show the outer electrons in this molecule.

(2)

F

F   Si   F

F

(f) The table shows the boiling points of some compounds containing silicon. All of these compounds contain covalent bonds.

Compound	Boiling point in °C
SiF_4	−86
$SiCl_4$	58
SiO_2	2950

SiF_4 and $SiCl_4$ have simple molecular structures.

SiO_2 has a giant covalent structure.

(i) Explain why the boiling point of $SiCl_4$ is greater than the boiling point of SiF_4

(2)

....

....

....

....

....

....

(ii) Explain why the boiling point of SiO_2 is very much greater than the boiling point of $SiCl_4$

(2)

....

....

....

....

....

....

(Total for Question 2 = 11 marks)

3 This apparatus can be used to investigate electrolysis.

NaCl(aq)

CuSO$_4$(aq)

solid PbBr$_2$

+   −

power supply
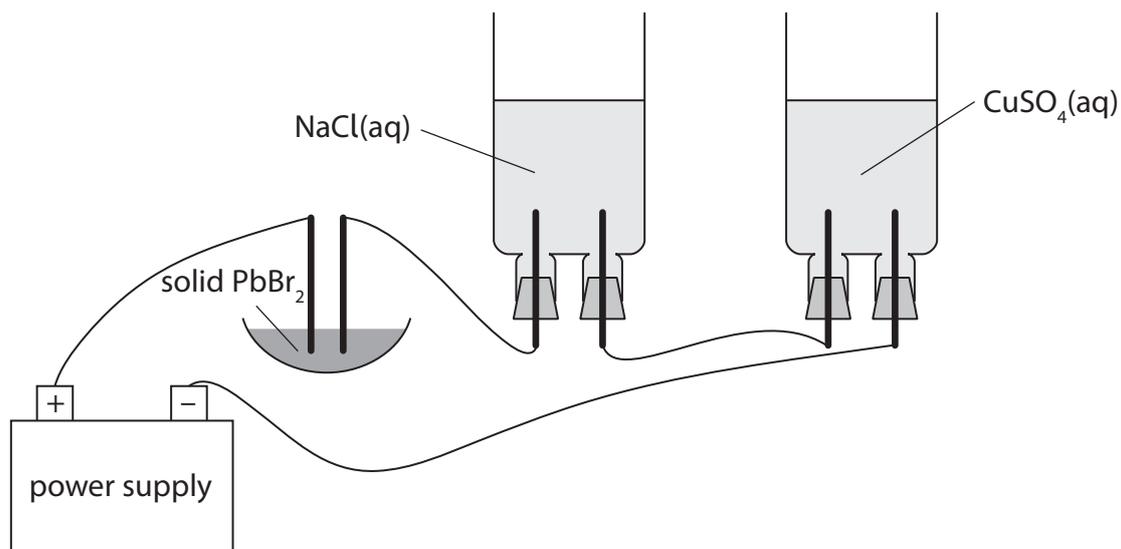
(a) Name the particles that move through the connecting wires to form an electric current.

(1)

....

(b) The electrodes are made of platinum, which is an inert metal.

State what is meant by the term **inert**.

(1)

....

....

(c) Explain why the electrolytic cell containing PbBr$_2$ needs to be heated before electrolysis can occur.

(2)

....

....

....

....

(d) When NaCl(aq) is electrolysed, two gases form at the positive electrode and one gas forms at the negative electrode.

The formulae of the species in NaCl(aq) are Na^+, Cl^-, H^+, OH^- and H_2O.

(i) Name the gases formed at each electrode.

(2)

positive electrode .... and ....

negative electrode...

(ii) Give ionic half-equations to show the formation of each gas.

(3)

....

....

....

....

....

....

(e) The ionic half-equation for one of the reactions in the cell containing copper(II) sulfate solution is

$$Cu^{2+} + 2e^- \rightarrow Cu$$

During the electrolysis, a charge of 0.040 faradays passes through this cell.

Calculate the mass of copper metal formed.

(2)

mass of copper = ... g

(Total for Question 3 = 11 marks)

4 Compounds containing C=C double bonds are used to manufacture alcohols such as ethanol and addition polymers such as PVC.

The table shows the formulae of some compounds containing C=C bonds.

A	B
$CH_2{=}CH_2$	H—C=C—C—H with H, H, H above and H below
C	**D**
C_4H_8	C_2H_3Cl

(a) (i) Explain which three of these compounds are hydrocarbons.

(2)

....

....

....

....

....

(ii) Explain which compound is shown as a displayed formula.

(2)

....

....

....

....

(b) Ethanol can be manufactured from compound A using reaction 1.
Ethanol can also be manufactured from glucose using reaction 2.

The equations for these reactions are

reaction 1 $C_2H_4 + H_2O \rightarrow C_2H_5OH$

reaction 2 $C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$
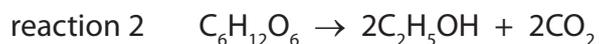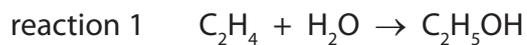
Give two advantages of using each reaction to manufacture ethanol.

(4)

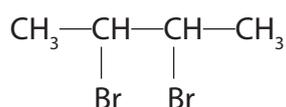reaction 1 ....

....

....

....

reaction 2 ....

....

....

....

(c) Compound C reacts with bromine to form a product with this formula.

$$CH_3\!-\!CH\!-\!CH\!-\!CH_3$$
$$\quad\;\; |\quad\;\; |$$
$$\quad\;\; Br\quad Br$$

(i) Use this formula to determine the name of compound C.

(2)

....

(ii) State the colour of the product formed when compound C reacts with bromine.

(1)

....

(d) Compound X is an isomer of compound C.

(i) Explain what is meant by the term **isomers**.

(2)

....

....

....

....

(ii) The equation for the conversion of compound X to an alcohol is

$$CH_2\!\!=\!\!CH\!-\!CH_2\!-\!CH_3 + H_2O \rightarrow CH_3\!-\!CH\!-\!CH_2\!-\!CH_3$$
$$|$$
$$OH$$
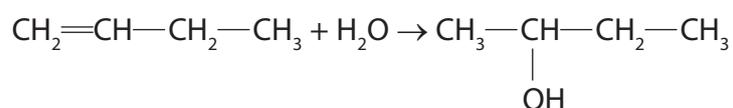
Place ticks (✓) in the boxes to show the two correct descriptions of this reaction.

(2)

addition	
dehydration	
hydration	
oxidation	
reduction	

(e) Compound D, chloroethene, can be used to manufacture the polymer PVC.

(i) State the full name of PVC.

(1)

....

(ii) Write an equation, containing displayed formulae, to represent the reaction that occurs in the manufacture of PVC.
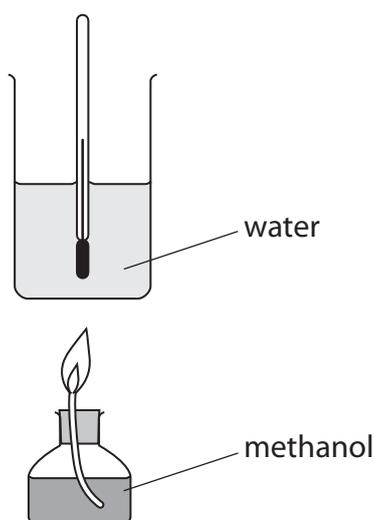
(3)

(Total for Question 4 = 19 marks)

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5 A student uses this apparatus to find the increase in temperature of water when methanol, CH_3OH, is burned.

water

methanol

(a) There are several reasons why the increase in temperature is less than expected.

(i) One reason is the incomplete combustion of methanol to form only carbon monoxide and water.

Write the chemical equation for this incomplete combustion.

(2)

....

(ii) State another reason why the increase in temperature is less than expected.

(1)

....

....

(b) The student records these results.

mass of burner and methanol before combustion	84.7 g
mass of burner and methanol after combustion	83.2 g
mass of water	125 g
temperature of water at start	22 °C
temperature of water at end	58 °C

(i) Calculate the heat energy change (Q), in joules, in this experiment using the expression

$$Q = m \times 4.2 \times \Delta T$$

where m is the mass of water in grams and ΔT represents the increase in temperature.

(2)

$Q =$ .... J

(ii) The relative molecular mass of methanol is 32

Use this information and your value for Q to calculate the molar enthalpy change, ΔH, for the combustion of methanol.

Give your answer in kJ/mol.

(4)

$\Delta H =$ .... kJ/mol

Turn over ▶

(iii) The student draws an energy level diagram for the complete combustion of methanol.

energy

methanol

carbon dioxide and water
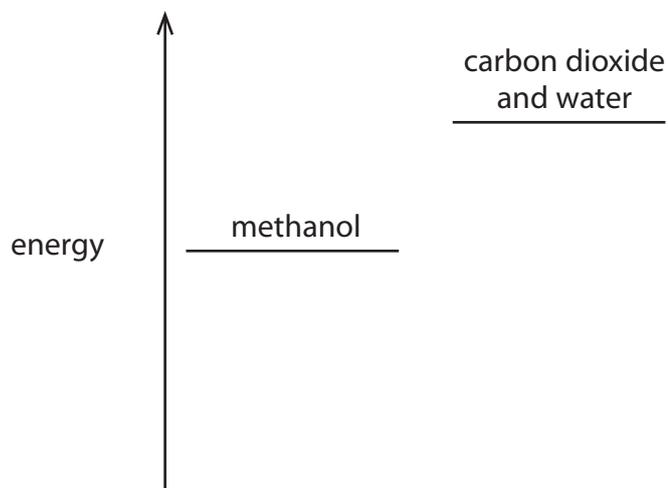
Identify the two mistakes in his diagram.

(2)

1 ....

....

2 ....

....

(c) The student is given this table of average (mean) bond energies.

Bond	C—H	C—O	O—H	O=O	C=O
Average bond energy in kJ/mol	412	360	463	496	743

The equation for the complete combustion of methanol is

$$\begin{array}{c} H \\ | \\ H-C-O-H \\ | \\ H \end{array} + 1.5\ O{=}O \rightarrow O{=}C{=}O + 2H-O-H$$
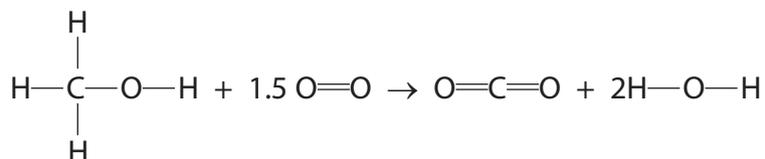
Use this equation and the information in the table to calculate another value for the molar enthalpy change, ΔH, for the combustion of methanol.

(4)

ΔH = ... kJ/mol

(Total for Question 5 = 15 marks)

TOTAL FOR PAPER = 60 MARKS

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