NAME:	CLASS:	INDEX NO:

QUEENSWAY SECONDARY SCHOOL

PRELIMINARY EXAMINATION 2022

SECONDARY 4 EXPRESS

Parent's Signature:

CHEMISTRY **6092/02**

Paper 2 **13 September 2022**

1 hour 45 minutes

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name and index number on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A:
Answer **all** questions in the spaces provided.

Section B:
Answer all **three** questions, the last question is in the form either/or.
Answer **all** questions in the spaces provided.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.
A copy of the Periodic Table is printed on page 25.

The use of an approved scientific calculator is expected, where appropriate.

	For Examiner's Use	
	Section A	/50
	Q9	/12
	Q10	/ 8
E / O	Q11	/10
	TOTAL	/80

SECTION A

Answer **all** the questions in this section in the spaces provided.
The total mark for this section is 50.

A1 Atoms or ions that contain the:

- same number of electrons are isoelectronic particles;
- same number of neutrons are isotonic particles; and
- same number of protons are isoprotic particles.

The nuclide notations of five ions are given below.

$^{31}_{15}V^{3-}$, $^{32}_{15}W^{2-}$, $^{32}_{17}X^{-}$, $^{31}_{15}Y^{-}$, $^{35}_{17}Z^{-}$

(a) Which of the five ions are

(i) isoelectronic;

…… [1]

(ii) isotonic; and

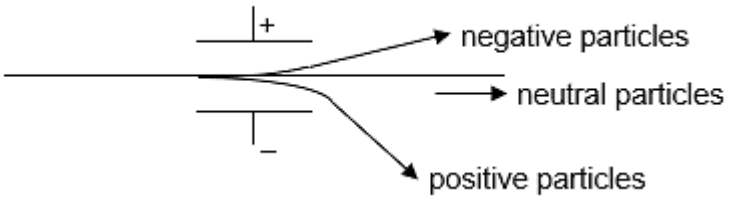
…… [1]

(iii) isoprotic?

…… [1]

(b) A beam of charged particles is deflected when they passed through an electric field.

Particles with higher charge and lower mass are deflected more.



When passed through an electric field, which of the five ions would be deflected the

(i) most?

…… [1]

(ii) least?

…… [1]

[Total: 5]

A2 The table below shows the melting points of some aluminium compounds.

aluminium compound	melting point / °C
Al_2O_3	2072
AlF_3	1291
$AlCl_3$	180

(a) With reference to the melting points given, suggest the structure and bonding of aluminium chloride.

structure ……..…….

bonding ……..…….. [1]

(b) **(i)** Draw the 'dot-and-cross' diagram for aluminium oxide.
Show outer electrons only.

[2]

(ii) Explain why the melting point of aluminium oxide is higher than that of aluminium fluoride.

……..

……..

…… [1]

(iii) Describe and explain one **other** physical property of aluminium oxide.

……..

……..

……..

…… [2]

[Total: 6]

A3 Carbon monoxide is used to make phosgene, $COCl_2$, which is an important reactant in industries to make polymers, dyes, and pharmaceuticals.

Phosgene was first made in 1812 by using a photochemical reaction in which a mixture of carbon monoxide and chlorine was exposed to bright sunlight.

$$CO + Cl_2 \rightleftharpoons COCl_2$$

It has been determined that phosgene melts at –118°C and boils at 8°C.

(a) Explain, using bonding and structure, why phosgene has low melting and boiling points.

……

……

..... [2]

(b) Describe the change in **arrangement** and **movement** of the particles of phosgene when the temperature decreases from –110 °C to –130 °C.

……

……

……

……

..... [2]

(c) Draw a 'dot-and-cross' diagram for phosgene, $COCl_2$.
Show outer shell electrons only.

[2]

[Total: 6]

A4 Hydrogen peroxide, H_2O_2, is both an oxidising agent and a reducing agent.

Reactions 1 and **2** below illustrate this property of hydrogen peroxide.

Reaction 1

$2KI(aq) + H_2O_2(aq) + H_2SO_4(aq) \rightarrow I_2(aq) + K_2SO_4(aq) + 2H_2O(l)$

Reaction 2

$2KMnO_4(aq) + 5H_2O_2(aq) + 3H_2SO_4(aq) \rightarrow K_2SO_4(aq) + 5O_2(g) + 2MnSO_4(aq) + 8H_2O(l)$

(a) In which reaction is hydrogen peroxide acting as an oxidising agent?

Explain your answer.

……

……

…….. [1]

(b) State the oxidation states of manganese in:

$KMnO_4$: …….

$MnSO_4$: ……. [1]

(c) Describe two observations from **Reaction 2**.

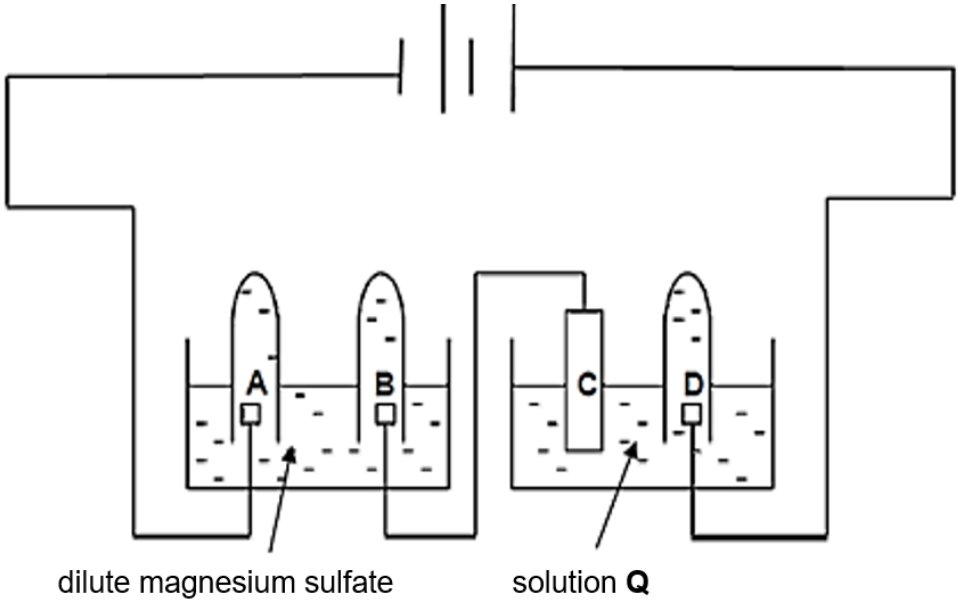
……

……

..... [2]

[Total: 4]

A5 The following set-up can be used for the electrolysis of solution **Q** and dilute magnesium sulfate solution using graphite electrodes.



(a) **(i)** Write the half-equations with state symbols to show the reactions taking place at electrodes **A** and **B**.

electrode **A**: ……

electrode **B**: …… [2]

(ii) State and explain the change in observation for electrode **A** when the electrolyte is changed to aqueous silver sulfate.

……

……

……

…… [2]

(b) In the electrolysis of solution **Q**, a reddish-brown deposit is observed at electrode **C** while a yellowish-green gas is observed at electrode **D**. The yellowish-green gas turns moist blue litmus paper red then bleaches it.

(i) Identify solution **Q**.

…… [1]

(ii) Calculate the volume of gas formed at electrode **D** if the volume of gas produced at electrode **B** is 30 cm^3.

[2]

[Total: 7]

A6 A student places a few drops of aqueous potassium iodide on a white tile and adds a few drops of chlorine water. The student observes that the solution darkens in colour.

(a) Explain the student's observation.

……

……

…….. [2]

(b) Describe how the student could extend this experiment and use his observations to show that the reactivity of bromine is placed between that of chlorine and iodine.

……

……

……

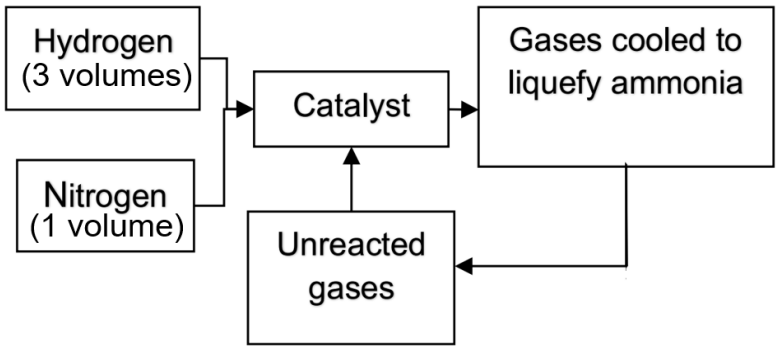
……

…….. [2]

[Total: 4]

A7 The Haber process, which converts hydrogen and nitrogen to ammonia, is one of the most important industrial chemical reactions to be developed. The process made ammonium-based fertilisers widely available, causing a world population boom as food production increased rapidly in a short period.

The diagram shows a simplified flowchart of the Haber Process in a reactor.



(a) State the source of each raw material in the Haber Process.

hydrogen: ……

nitrogen: …… [1]

(b) When the mixture of gases is cooled, only ammonia changes into a liquid.

Explain this observation with reference to its boiling point.

……

…… [1]

(c) Explain why the volume ratio of nitrogen to hydrogen in the reactor is maintained at 1 : 3.

……

……

……[2]

(d) The ammonia produced from the Haber process is used to make fertilisers. Ammonium-based fertilisers are often added to soil to provide nitrogen to stimulate plant growth. However, it is not recommended for ammonium-based fertilisers to be added to acidic soils that have just been treated with calcium hydroxide.

Explain why this is so.

……

……

……[2]

(e) The Haber process accounts for roughly 1% of the global carbon dioxide emissions.

Describe **two** ways in which the Haber process contributes to the global carbon dioxide emissions.

……

……

……

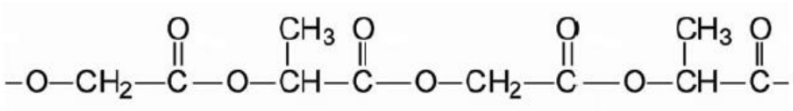
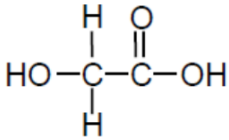
……[2]

[Total: 8]

A8 Polymers are widely used in various medical applications due to their properties.

Poly(lactic-co-glycolic acid), PLGA, is a biodegradable polymer that is used as an adhesive material to dress surgical wounds due to its biocompatibility. PLGA is synthesized by the polymerisation of two different monomers, lactic acid and glycolic acid.

The structures of a part of the PLGA and its monomer glycolic acid are shown below.

name	structure
poly(lactic-co-glycolic acid) (PLGA)	
glycolic acid	

(a) Name the type of linkage in PLGA.

……[1]

(b) What is the relative molecular mass of the repeating unit of PLGA?

Show your working.

[2]

(c) Draw the full displayed formula of the lactic acid monomer.

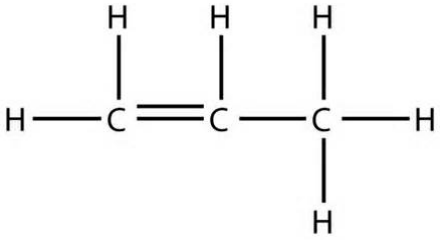
[2]

(d) Draw the full structural formula of the organic molecule formed when glycolic acid is warmed with excess acidified potassium manganate(VII).

[1]

(e) Poly(propene), PP, is another example of synthetic polymers used in medical applications. Due to its high chemical and bacterial resistance, PP is commonly used to make disposable syringes.

PP is formed from the polymerisation of propene.



propene

(i) Draw the structure of PP which shows **two** repeating units.

[1]

(ii) PP is an addition polymer. PLGA is a condensation polymer.

Describe **three** differences between the synthesis of polymers by addition polymerisation and by condensation polymerisation.

……..

……..

……..

……..

……..

……..

……..

……..

……..[3]

[Total: 10]

END OF SECTION A

SECTION B

Answer all **three** questions in this section.

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B9 This question is about two methods which can be used to manufacture hydroiodic acid, HI.

Method 1: Reaction of aqueous iodine with propanone

Aqueous iodine reacts with propanone, CH_3COCH_3, in the presence of an acid catalyst to form iodopropanone and hydroiodic acid.

$$I_2(aq) + CH_3COCH_3(aq) \rightarrow CH_2ICOCH_3(aq) + HI(aq)$$

In an experiment using 0.002 mol/dm^3 of aqueous iodine, the change in concentration of propanone was measured as the reaction progressed. The results are shown in **Fig. 9.1.**

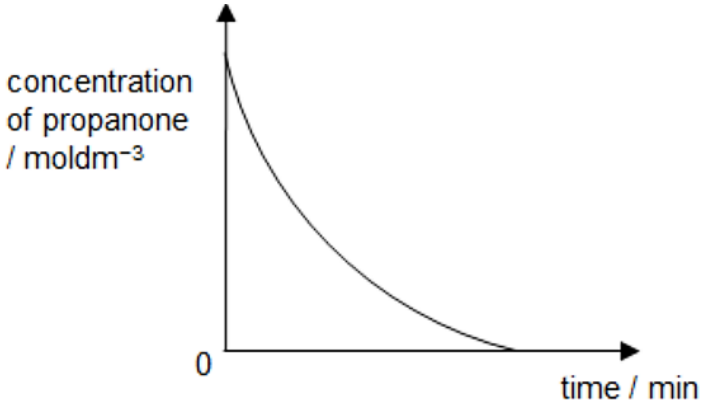


Fig. 9.1

Initial rate of reaction

The initial rate of a reaction is the instantaneous rate at the start of a reaction. It can be calculated from a concentration-time graph by finding the gradient of the graph at t = 0.

Two sets of experiments were conducted to determine how the concentration of aqueous iodine and propanone affect the initial rate of reaction.

In **experiment 1**, different concentrations of propanone were reacted with a fixed concentration of iodine. **Fig. 9.2** shows how the concentration of iodine changes with time using different concentrations of propanone.

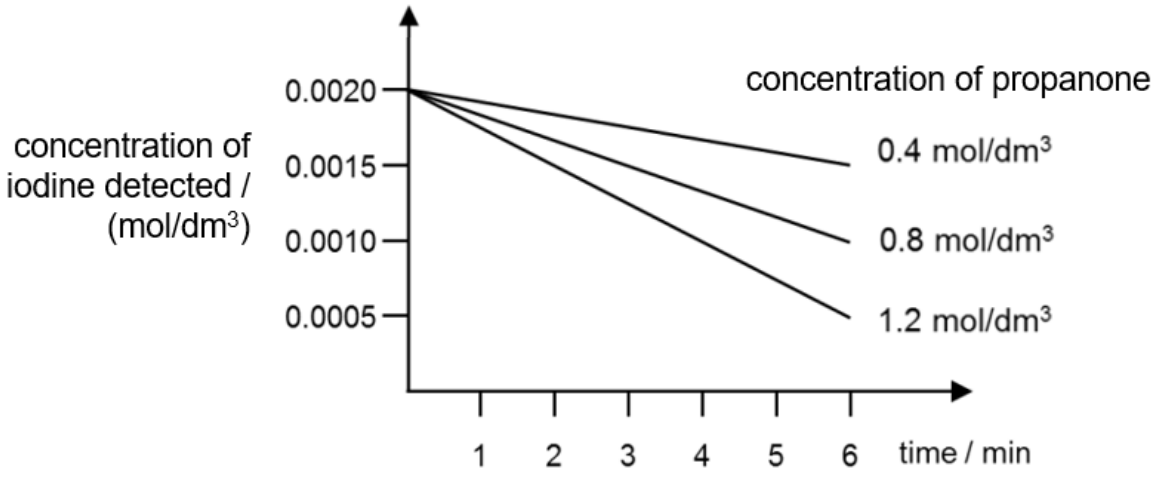


Fig. 9.2

In **experiment 2**, different concentrations of iodine were reacted with a fixed concentration of propanone. **Fig. 9.3** shows how the concentration of iodine changes with time using different concentrations of iodine.

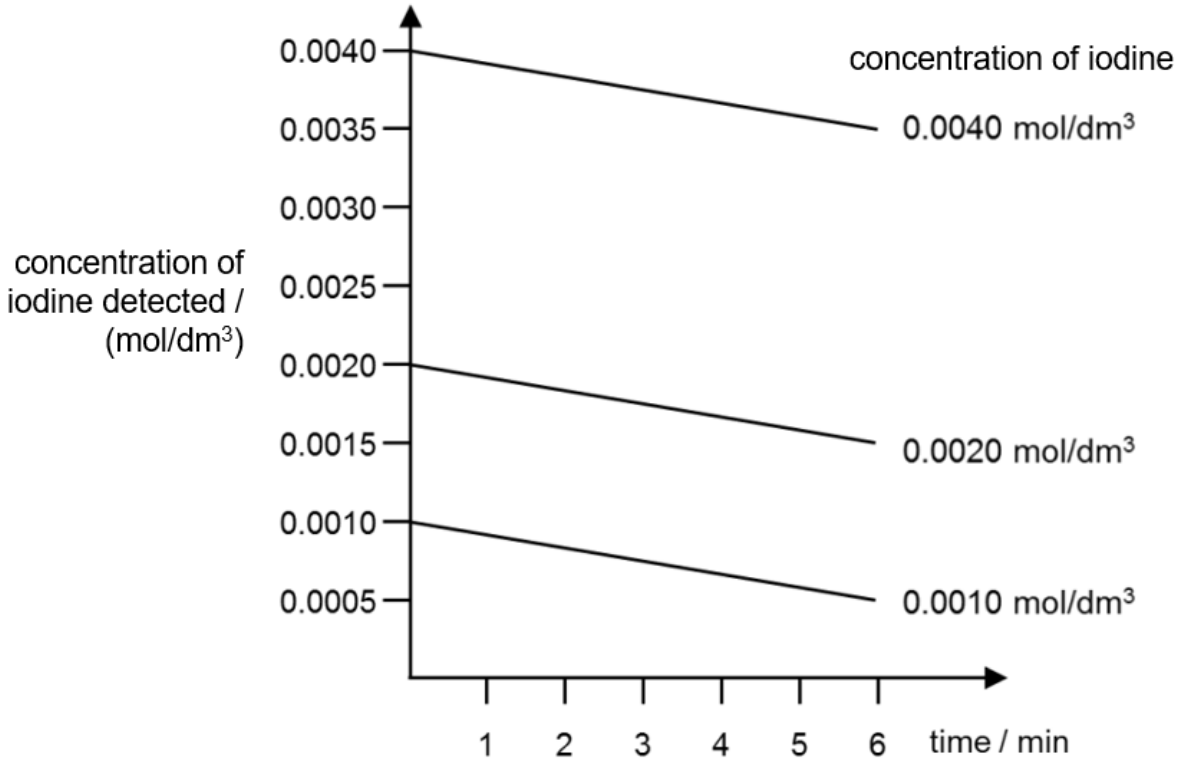


Fig. 9.3

Method 2: Reaction of iodine with hydrazine

The industrial preparation of HI involves the reaction of iodine with hydrazine, N_2H_4. Nitrogen gas is produced as the only by-product.

During the reaction, more energy is released during the forming of bonds in the products than energy absorbed during the breaking of bonds in the reactants.

(a) Name the type of reaction between iodine and propanone as shown in **Method 1**.

……[1]

(b) Using information from **Fig. 9.1**, deduce which reagent, iodine or propanone, is in excess in this reaction. Explain your answer.

……

……[1]

(c) Describe how the initial rate of reaction is affected by the

(i) concentration of propanone. Support your answer using information from **Fig. 9.2**.

……..

……..

……..

……[2]

(ii) concentration of iodine. Support your answer using information from **Fig. 9.3**.

……..

……..

……..

……[2]

(d) The reaction of iodine with hydrazine in **Method 2** is a redox reaction.

(i) Write a balanced chemical equation for the reaction of iodine and hydrazine. State symbols are not required.

……..[1]

(ii) Explain, in terms of oxidation numbers, why the reaction of iodine and hydrazine is a redox reaction.

……..

……..

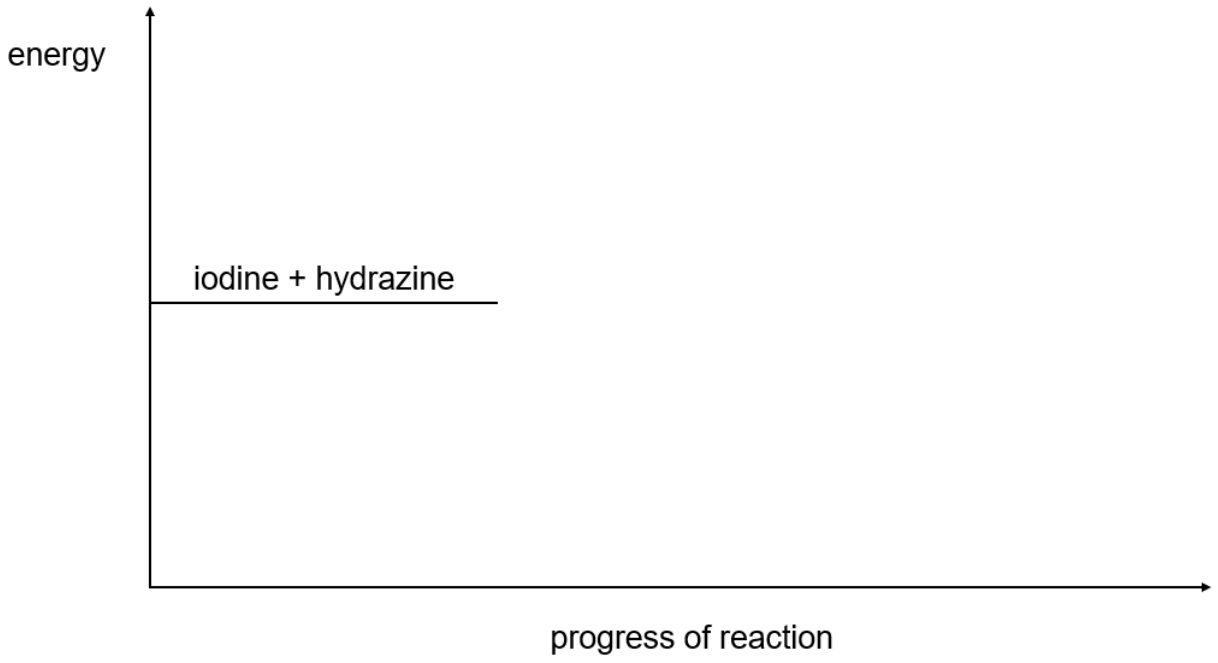
……..

……..[2]

(e) Complete the energy profile diagram for the reaction between iodine and hydrazine in **Method 2**.

Your diagram should include:

- the names of the products of the reaction,
- labels to show the enthalpy change of reaction and the activation energy.



[3]

[Total: 12]

B10 Alkenes and alkynes are examples of unsaturated hydrocarbons. Alkenes contain carbon-carbon double bond (C=C) whereas alkynes contain carbon-carbon triple bond (C≡C). Alkenes can exist as straight chain or branched hydrocarbons.

Table 10.1 shows the boiling points of some straight chain alkenes.

Table 10.1

name	molecular formula	boiling point/ °C
ethene	C_2H_4	-104
propene	C_3H_6	- 47
butene	C_4H_8	- 6
pentene	C_5H_{10}	30

Table 10.2 shows some properties of branched isomers of butene and pentene.

Table 10.2

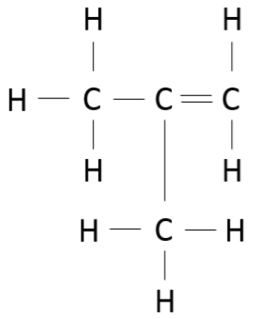
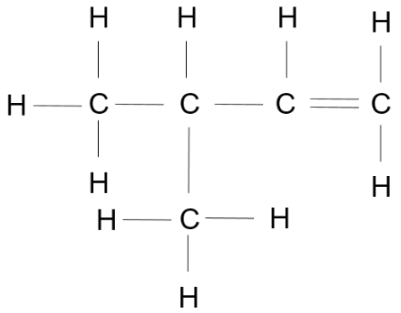
	number of carbon atoms in molecule	structural formula	boiling point / °C
branched alkene 1	4		-7
branched alkene 2	5		20

Table 10.3 shows some properties of the first four members of the alkyne homologous series.

Table 10.3

name	molecular formula	boiling point/ ^{o}C
ethyne	C_2H_2	- 84
propyne	C_3H_4	- 23
butyne	C_4H_6	8
pentyne	C_5H_8	40

(a) How is the boiling point of a straight chain alkene affected by branching in isomerism? Use evidence from **Table 10.1** and **Table 10.2** to explain your reasoning.

……

……

……

……

……

……...[2]

(b) Alkynes are an example of a homologous series.

Explain how the formulae of alkynes in **Table 10.3** show this.

……

……...[1]

(c) Draw the full structural formula of propyne.

[1]

(d) State a reagent and describe the observations which could be used to distinguish an alkyne from an alkane.

reagent ……

observation for alkyne ……..…..…….

…….....

observation for alkane …….……..……

……...[2]

(e) **Branched alkene 1** in **Table 10.2** is reacted with steam.

(i) Draw the full structural formulae of the **two** possible products formed from this reaction.

[1]

(ii) Explain why the two products in **(e)(i)** are isomers of each other.

…….

…… [1]

[Total: 8]

EITHER

B11 Phosphorus exists in several forms, such as white phosphorus and phosphorene.

Phosphorene, or thin-layer black phosphorus, was recently discovered by scientists and held exciting opportunities for its application such as electronic devices and photodetectors.

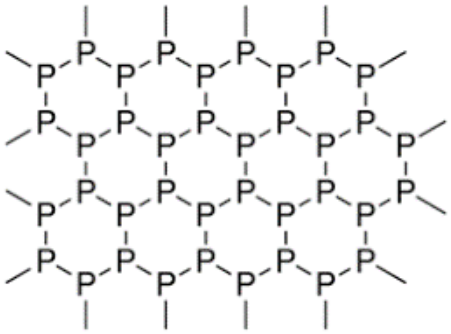
(a) State the term used to describe the different forms of phosphorus.

…….. [1]

(b) Phosphorene is made up of a few layers of phosphorus atoms that are arranged hexagonally in each layer.

Adjacent layers of atoms are held together by weak forces of attraction.

A section of a monolayer of phosphorene is shown.



Using concepts involving chemical bonding, suggest and explain **two** physical properties of phosphorene.

……

……

……

……

……

..... [4]

(c) Phosphorus is a vital plant nutrient and potassium phosphate is a common fertiliser that provides plants with this essential mineral when added to soil.

Potassium phosphate is a soluble salt that can be prepared by the following steps.

1. Dissolve solid potassium carbonate in water.
2. React aqueous potassium carbonate with phosphoric acid

$$3K_2CO_3 + 2H_3PO_4 \rightarrow 2K_3PO_4 + 3H_2O + 3CO_2$$

3. Crystalise potassium phosphate.

During the manufacturing process, 1.75 kg of impure potassium carbonate is dissolved in water in step 1.

Given that 180 dm^3 of carbon dioxide is evolved in step 2, calculate the percentage purity of potassium carbonate.

[3]

(d) Phosphorus and nitrogen react with hydrogen to form phosphine, PH_3, and ammonia, NH_3, respectively.

Explain why phosphorus and nitrogen are chemically similar.

……

……

……

…… [2]

[Total: 10]

OR

B11 Malachite is an ore of copper, containing a copper carbonate hydroxide mineral, $Cu_2CO_3(OH)_2$.

(a) Starting with a powdered sample of malachite, describe an experimental procedure that you may conduct to show that malachite contains copper(II) ions.

……

……

……

……

..... [3]

(b) Copper can be extracted from malachite by a two-stage process.

Stage 1: Malachite is heated to decompose it into copper(II) oxide, carbon dioxide and water vapour.

Stage 2: Copper(II) oxide is heated with coke to reduce it to form copper.

Write **two** balanced chemical equations to show the reactions involved in this extraction process.

……

..... [2]

(c) A sample of malachite was found to contain 16.5% of other substances apart from $Cu_2CO_3(OH)_2$.

Calculate the mass of copper that can be extracted from 2 tonnes of this sample of malachite.

[3]

(d) Draw a labelled diagram to show how the extracted copper can be purified by electrolysis.

[2]

[Total: 10]

END OF PAPER

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids	72 Hf hafnium 178	73 Ta tantalum 181	74 W tungsten 184	75 Re rhenium 186	76 Os osmium 190	77 Ir iridium 192	78 Pt platinum 195	79 Au gold 197	80 Hg mercury 201	81 Tl thallium 204	82 Pb lead 207	83 Bi bismuth 209	84 Po polonium –	85 At astatine –	86 Rn radon –
87 Fr francium –	88 Ra radium –	89 – 103 actinoids	104 Rf Rutherfordium –	105 Db dubnium –	106 Sg seaborgium –	107 Bh bohrium –	108 Hs hassium –	109 Mt meitnerium –	110 Ds darmstadtium	111 Rg roentgenium	112 Cn copernicium –		114 Fl flerovium –		116 Lv livermorium –		

lanthanoids	57 La lanthanum 139	58 Ce cerium 140	59 Pr praseodymium 141	60 Nd neodymium 144	61 Pm promethium –	62 Sm samarium 150	63 Eu europium 152	64 Gd gadolinium 157	65 Tb terbium 159	66 Dy dysprosium 163	67 Ho holmium 165	68 Er erbium 167	69 Tm thulium 169	70 Yb ytterbium 173	71 Lu lutetium 175
actinoids	89 Ac actinium –	90 Th thorium 232	91 Pa protactinium 231	92 U uranium 238	93 Np neptunium –	94 Pu plutonium –	95 Am americium –	96 Cm curium –	97 Bk berkelium –	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).