Name	Class	Register Number

6092/02
CHEMISTRY

24/S4Prelim/6092/2

PAPER 2

Tuesday **27 August 2024** **1 hour 45 minutes**

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VICTORIA SCHOOL

PRELIMINARY EXAMINATION
SECONDARY FOUR

READ THESE INSTRUCTIONS FIRST

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

Section A
Answer **all** questions.
Write your answers in the spaces provided.

Section B
Answer **one** question.
Write your answers in the spaces provided.

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.

Section A	**/ 70**
Section B	**/ 10**
Total	**/ 80**

Deductions	
Presentation	
Significant Figures	
Units	

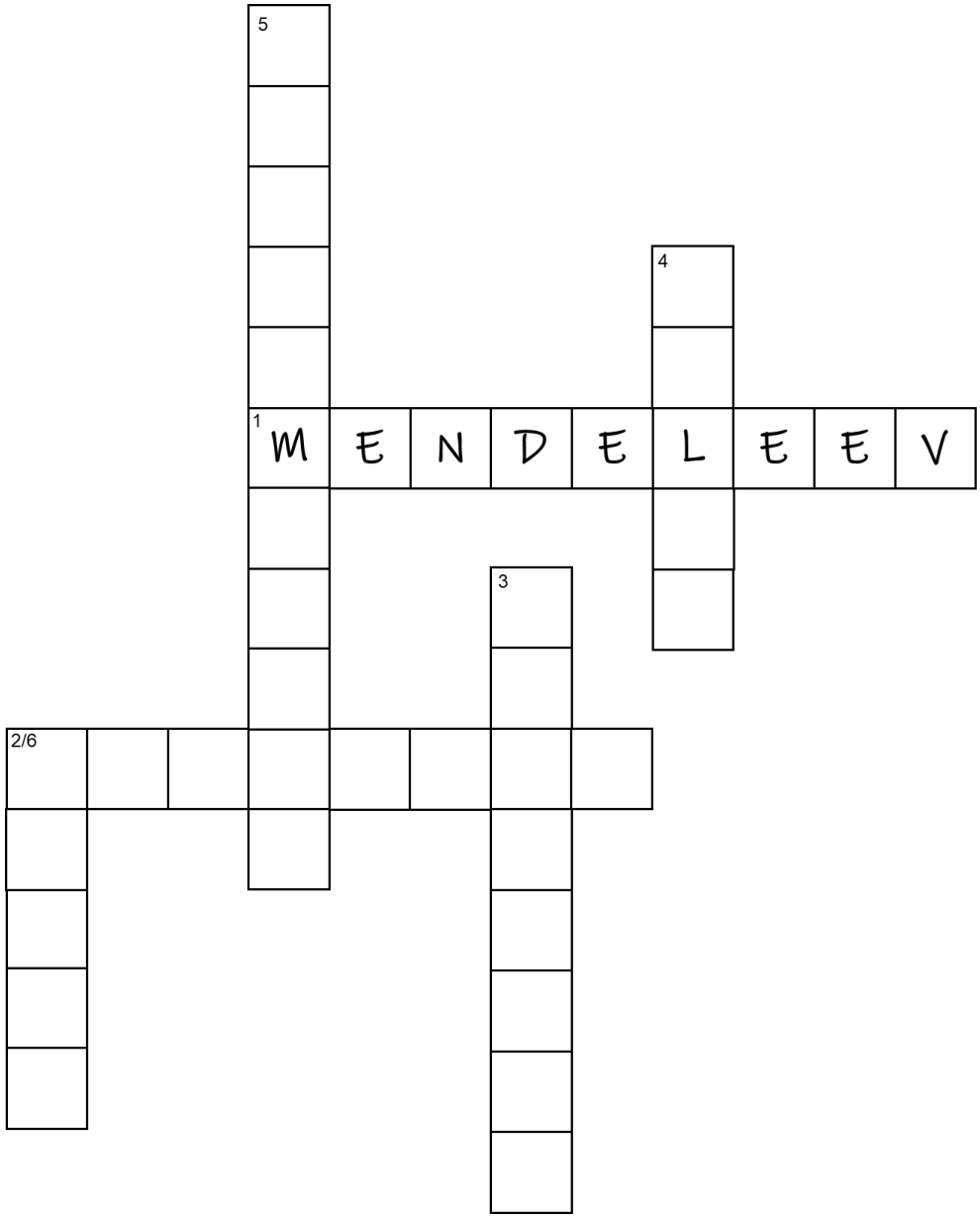
This question paper consists of 25 printed pages, including the cover page.

[Turn Over

Section A (70 marks)

Answer all the questions in this section in the spaces provided.

A1 Read the clues below to fill in the crossword puzzle. The first one has been done for you.



Across

(1) inventor of the Periodic Table

(2) the particle formed when an atom with proton number 9 is ionised

Down

(3) the reaction of steam with ethene is an example of an …….reaction

(4) steel is an example of an ……

(5) the method used to separate a solid sample of iodine and sodium chloride

(6) pure substances have a …… melting point [5]

[Total:5]

A2 Some elements burn in air to form oxides.

In an experiment, sodium was burnt in a sealed container. The products were then added to a flask containing a solution of Universal Indicator.

In a second experiment, the reaction was repeated with burning carbon instead of sodium.

(a) State what you would observe with the Universal Indicator in each experiment.

experiment using sodium: ……

experiment using carbon: ……[1]

(b) Sodium oxide forms during the first experiment.

Draw a 'dot-and-cross' diagram to show the arrangement of outer shell electrons in the compound of sodium oxide.

[2]

(c) In another experiment, 2.30 g of sodium was combusted.

Table 2.1 shows the mass of the flask and contents before and after the experiment.

Table 2.1

mass of flask and contents at start / g	94.50
mass of flask and contents at end / g	94.82

Calculate the percentage yield of sodium oxide.

[3]

[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. This reaction is exothermic.

$$CO + Cl_2 \rightleftharpoons COCl_2$$

(a) (i) Explain, in terms of bond breaking and bond making, why the formation of phosgene is an exothermic reaction.

……

……

……[2]

(ii) Explain, in terms of oxidation state, if the formation of phosgene is a redox reaction.

……

……

……[2]

(b) Fig. 3.1 below shows the heating curve of phosgene.

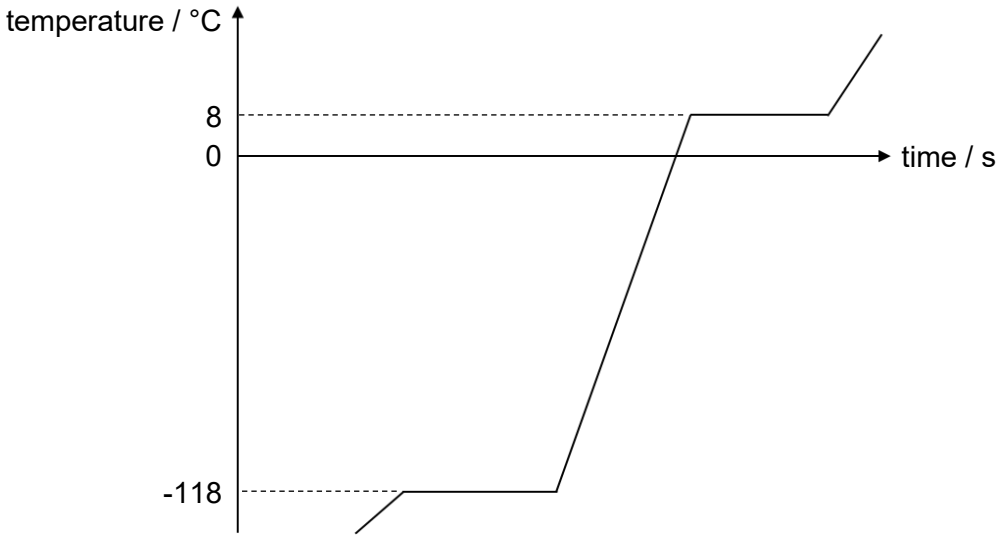


Fig. 3.1

Describe the changes in the arrangement and movement of the molecules of phosgene when the temperature is increased from –128 °C to –108 °C.

……

……

……

……[2]

[Total: 6]

A4 Catalysis is the increase in rate of a chemical reaction due to an added substance known as a catalyst.

Catalysts generally react with one or more reactants to form intermediates that subsequently give the final reaction product.

(a) Catalysts are often expensive.

Explain why it is still economically viable to use them.

……...

……...

……[2]

(b) Fig. 4.1 below shows a range of industrial catalysts in pellet form.

Fig. 4.1

Explain why the catalysts are supplied in pellet form.

Use ideas about particles in your answer.

……...

……...

……...

……[2]

(c) Naphthalene ($C_{10}H_8$) reacts with ethanoyl chloride (CH_3COCl) in the presence of a catalyst to form acetylnaphthalene ($C_{12}H_{10}O$) and hydrogen chloride through a two-step reaction.

Fig. 4.2 below shows the energy profile diagram for the catalysed reaction.

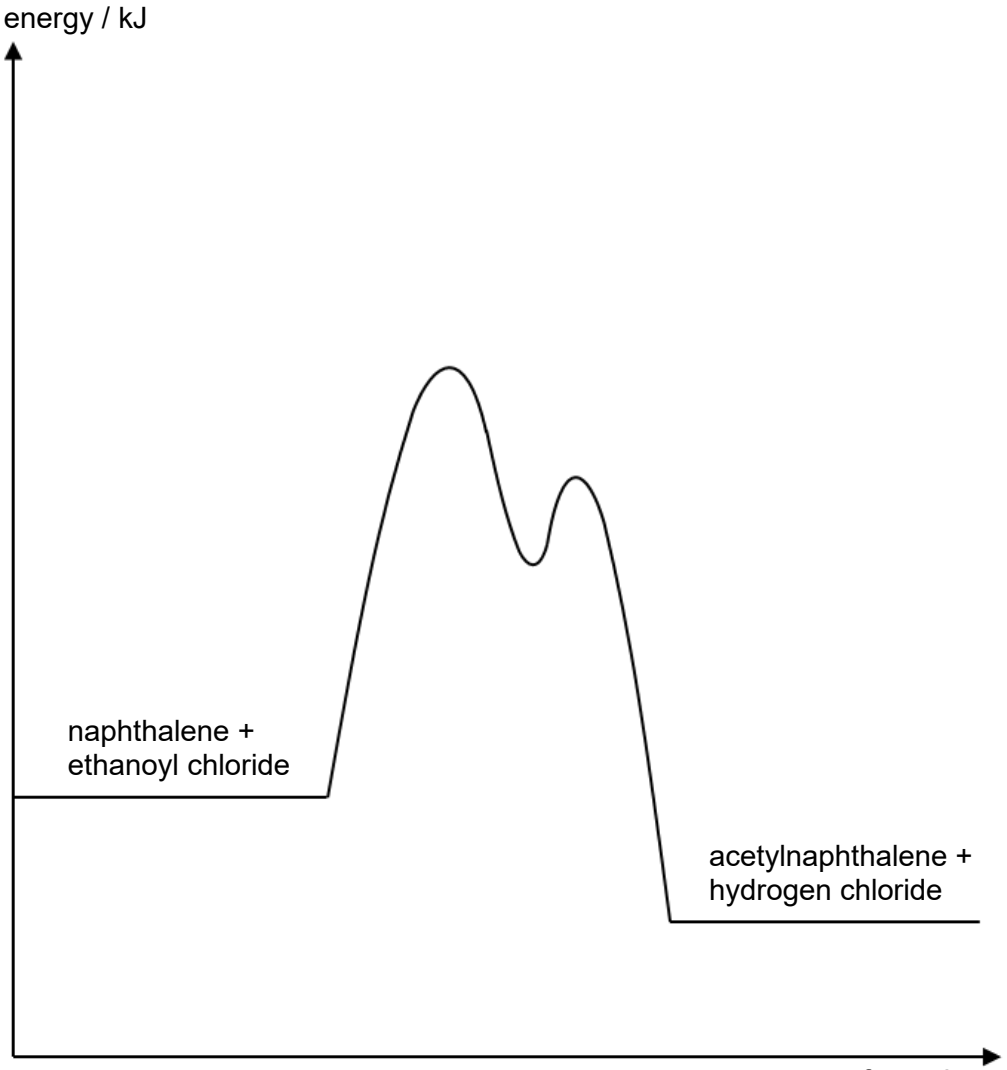


Fig. 4.2

(i) The uncatalysed reaction takes place in a single step.

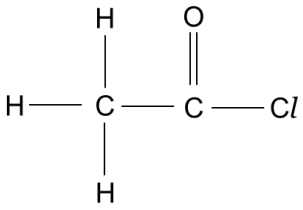
On Fig. 4.2, sketch the energy change graph for the uncatalysed reaction. [1]

(d) Ethanoyl chloride is an example of an acyl chloride.

Acyl chlorides react with alcohols, in a similar manner to carboxylic acids, to produce esters. The 2 main differences are:

- The reaction is irreversible.
- Hydrogen chloride is removed instead of water.

The structure of ethanoyl chloride is shown below.



(i) Name the ester produced when ethanoyl chloride reacts with methanol.

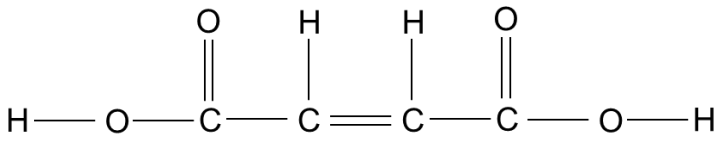
……[1]

(ii) Write a chemical equation for the above reaction, showing all organic substances as full structural formula.

[2]

[Total: 8]

A5 The structure of substance **X** is shown below.



Substance **X** undergoes condensation polymerisation with diaminobutane ($H_2N(CH_2)_4NH_2$).

(a) Draw the structure of the polymer formed when substance **X** reacts with diaminobutane.

[1]

(b) Substance **X** can also undergo addition polymerisation.

(i) Draw the repeating unit of the polymer formed.

[1]

(ii) State one difference between the reaction in **(a)** and the reaction in **(b)(i)**.

……

……[1]

(c) Draw an isomer of diaminobutane ($H_2N(CH_2)_4NH_2$) that still can undergo condensation polymerisation with substance **X**.

[1]

[Total:4]

A6 Nicotine is a highly addictive organic chemical produced naturally in the tobacco plant. It is commonly used as a recreational drug for its mood altering effects.

The percentage composition of nicotine is shown below in Table 6.1.

Table 6.1

element	percentage by mass (%)
carbon	74.1
hydrogen	8.6
nitrogen	17.3

(a) Nicotine has a molar mass of 162 g/mol.

Determine the molecular formula of nicotine.

[3]

(b) A cigarette provides on average 1 mg of nicotine when smoked.

A 2 cm^3 vape may contain a concentration as high as 0.123 mol/dm^3 of nicotine.

Calculate the mass, in mg, of nicotine present in a vape.
(1 g = 1000 mg)

[2]

(c) Smoking cigarettes produces carbon monoxide gas.

Explain why smoking cigarettes is harmful to smokers and those around them.

……..……...……

……..……

……..……...……[2]

(d) Nicotine can be extracted from dried tobacco leaves.

Nicotine melts at -79 °C and boils at 247 °C. It is soluble in organic solvents, like ethanol.

Table 6.2 shows the steps that need to be taken to extract nicotine from dried tobacco leaves.

(i) Arrange the following steps in the correct order to extract nicotine from dried tobacco leaves.

Table 6.2

step number	description
	Soak the ground tobacco in the ethanol solvent.
	Separate the nicotine-rich solution from the solid plant material using process **A**.
	Obtain nicotine from the mixture of ethanol and nicotine using process **B**.
	Stir the mixture to enhance the extraction of nicotine into the solvent.
	Grind the dried tobacco leaves into a fine powder.

[1]

(ii) Identify process **A** and **B**.

Process **A** ……

Process **B** …… [1]

[Total: 9]

A7 (a) Dichlorobutane, $CH_3CH_2CHClCH_2Cl$, is a useful chemical feedstock for making nylon.

Students **A** and **B** wanted to prepare a sample of dichlorobutane by using different methods as shown in table 7.1.

Table 7.1

student	method
A	Reacting butene with aqueous chlorine
B	Reacting butane with chlorine gas in the presence of UV light

Table 7.2 shows the statements about the preparation of dichlorobutane.

State whether the statements are true or false.

Table 7.2

statement		true / false
(i)	Both methods can be used to prepare dichlorobutane	
(ii)	Both methods require the same conditions.	
(iii)	Student **A**'s method will produce a higher percentage yield of dichlorobutane compared to student **B**'s method.	
(iv)	Student **B**'s method can lead to environmental problems.	

[2]

(b) Kerosene is one of the fractions obtained from distillation of crude oil.

Health officers often spray kerosene onto the surface of stagnant pools of water to kill mosquito larvae.

The larvae breathe via a tube that they extend to the water's surface, as show in Fig. 7.3 below.

With time, this kerosene layer will slowly evaporate away and hence re-spraying of kerosene is necessary.

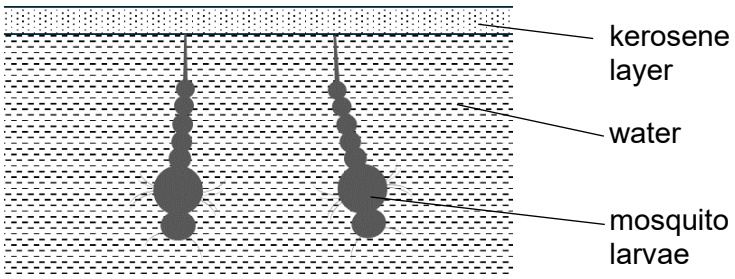


Fig. 7.3

(i) State two physical properties of kerosene and explain how they enable it to kill mosquito larvae.

……...……

……

……...……[2]

(ii) Kerosene has a higher relative molecular mass than petrol.

Suggest and explain, in terms of bonding and structure, why kerosene is more suitable than petrol for spraying onto the water to prevent dengue.

……...……

……

……...……[2]

[Total: 6]

A8 The Down's cell is a commercial electrochemical cell used to obtain sodium metal by the electrolysis of molten sodium chloride.

Fig. 8.1 shows a Down's cell.

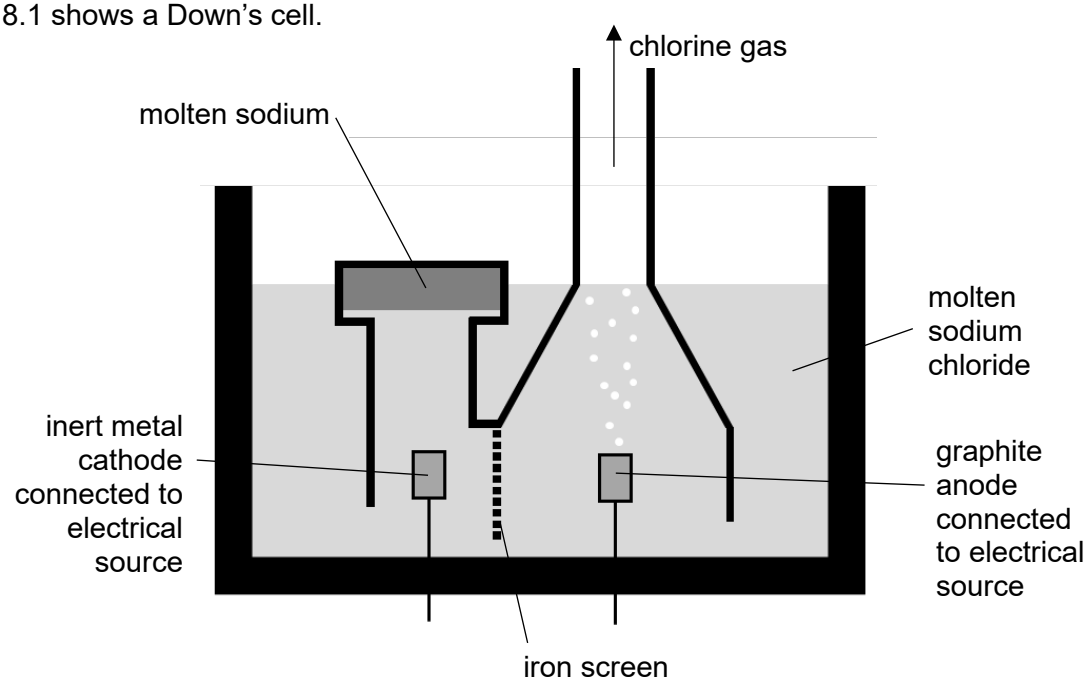


Fig. 8.1

(a) **(i)** The iron screen in the Down's cell is used to prevent the molten sodium from coming into contact with the chlorine.

Explain why this is necessary.

……...

……...[1]

(ii) A student claims that the products would be the same even if a concentrated aqueous solution of sodium chloride is used.

Do you agree? Give reasons for your answer.

……...

……...

……...[2]

(b) Explain, with the aid of a half equation, why chlorine gas cannot be obtained if the graphite anode is replaced by a copper anode.

……

……

……

……...[2]

(c) A student used moist blue litmus paper to test for chlorine gas. Upon seeing that the moist blue litmus paper turned red, he concluded chlorine gas must be present.

Do you agree with him?

Explain your answer.

……

……[1]

(d) Some chlorine gas was bubbled into a potassium iodide solution.

(i) Describe what would be observed after some time.

……

……[1]

(ii) Explain why a reaction occurred.

……

……[1]

[Total: 8]

A9 One method of determining the order of reactivity of metals is by measuring the voltage and polarity of simple cells.

The polarity of a cell is shown by which metal is the positive electrode and which metal is the negative electrode.

The following table gives the polarity of cells of four different metals **W**, **X**, **Y** and **Z**.

cell	electrode 1	polarity	electrode 2	polarity
1	**X**	—	**W**	**+**
2	**Y**	—	**W**	**+**
3	**Z**	**+**	**W**	—

(a) What information about the reactivity of the four different metals can be deduced from the table?

……

……

……[2]

(b) A student wants to determine whether metal **X** or **Y** is more reactive.

He decided to pass steam over the metals.

Describe how to carry out the tests, including any additional materials or reagents, and describe the results you would expect.

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……

……[4]

[Total: 6]

A10 Some compounds formed between fluorine and various non-metals are shown in Table 10.1 below.

Table 10.1

non-metal	C	N	O	Ne	Si	P	S	Ar
formula of compound	CF_4	NF_3	OF_2	no compound formed	SiF_4	PF_3	SF_2	no compound formed
melting point of compound / °C	-184	-207	-224	-	-90	-152	-	-

Student **A** examines the data in Table 10.1 and poses the following hypothesis:

The number of F atoms that will bond to a non-metal is always equal to 8 minus the number of valence electrons in the non-metal atom.

In an attempt to verify student **A**'s hypothesis, student **B** researches the molecules that form between halogens and fluorine, and assembles the following list shown in Table 10.2.

Table 10.2

halogen	formula of molecule
F	F_2
C*l*	C*l*F, C*l*F_3
Br	BrF, BrF_3, BrF_5
I	IF, IF_3, IF_5, IF_7

(a) Describe the trend of melting points of fluoride molecules across Period 2 shown in Table 10.1.

……

……[1]

(b) **(i)** Based on student **A**'s hypothesis, what should be the formula of the compound that forms between germanium and fluorine?

……[1]

(ii) Does the list assembled by student **B** support the hypothesis of student **A**?

Use the information provided to support your answer.

……

……

……[2]

(iii) Propose a hypothesis based on student **B**'s list to account for the molecules that form between halogens and fluorine.

……

……[1]

(iv) In terms of bonding, which compounds that form between halogens and fluorine are unusual?

Explain your answer.

……

……

……[2]

(c) Explain why there are no compounds formed between fluorine and non-metals such as neon and argon.

……

……[1]

(d) Astatine is from Group 17 in the Periodic Table.

Predict the formula of the compound formed when astatine reacts with sulfur.

Explain your answer.

……

……

……[2]

(e) Draw a 'dot-and-cross' diagram to represent the bonding in OF_2.

Show only the valence electrons.

[2]

[Total: 12]

Section B (10 marks)

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

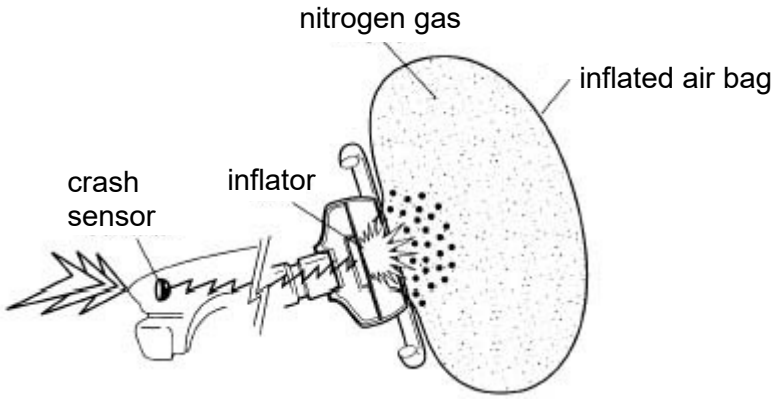
EITHER

B11 An airbag cushion is designed to inflate very rapidly then quickly deflate during collision.

The main chemical used in the airbag is sodium azide, NaN_3.

When a car is involved in a collision, the crash trip sensors in cars send an electric signal to an ignitor, which then generates heat to cause sodium azide to decompose as shown in the equation below.

$$2NaN_3(s) \rightarrow 2Na(l) + 3N_2(g)$$



The nitrogen gas is produced very rapidly and the air bag inflates almost immediately.

(a) If an automobile airbag has a volume of 11.7 dm^3, what is the minimum mass of sodium azide required to fully inflate the airbag?

[3]

(b) The airbag also contains potassium nitrate and silicon dioxide.

The sodium formed from the decomposition of sodium azide reacts with potassium nitrate as shown in the equation below.

$$10Na(l) + 2KNO_3(s) \rightarrow K_2O(s) + 5Na_2O(s) + N_2(g)$$

(i) Suggest one reason why the manufacturer of the air bag will want the above chemical reaction to take place.

……

……..[1]

(ii) The oxides formed will then further react with silicon dioxide to produce a silicate glass which is harmless and stable.

The silicate glass contains potassium silicate, K_2SiO_3 and sodium silicate, Na_2SiO_3.

Write a chemical equation for the formation of potassium silicate and sodium silicate.

[1]

(c) Sodium azide can also be used to make lead(II) azide, $Pb(N_3)_2$, a chemical compound that is used as a detonator for explosives.

This involves reacting sodium azide solution with lead(II) nitrate solution to produce a white powder of lead(II) azide and sodium nitrate solution.

(i) What is the name of the above chemical reaction?

……..[1]

(ii) Construct an ionic equation with state symbols for the formation of lead(II) azide.

[2]

(iii) Describe the method used to prepare a pure and dry sample of lead(II) nitrate using lead(II) carbonate as a starting material.

……

……

……

……

……..……..……[2]

[Total: 10]

OR

B11 Methylamine, CH_3NH_2, is a weak base. Its properties are similar to those of ammonia.

(a) The equation below shows what happens when methylamine is dissolved in water.

$$\underset{\text{base}}{CH_3NH_2} + \underset{\text{acid}}{H_2O} \rightleftharpoons CH_3NH_3^+ + OH^-$$

Using the equation, explain why water behaves as an acid and methylamine as a base.

……

……[1]

(b) An aqueous solution of sodium hydroxide has pH 13.

Predict the pH of an aqueous solution of methylamine which has the same concentration.

Give a reason for your choice of pH.

……

……[2]

(c) Methylamine can neutralise acids.

$$CH_3NH_2 + HCl \rightarrow \underset{\text{methylammonium chloride}}{CH_3NH_3Cl}$$

(i) Write the equation for the reaction between methylamine and sulfuric acid.

[1]

(ii) Methylammonium chloride can react with potassium hydroxide.

State the products of this reaction.

……[1]

(d) Aqueous methylamine is added to aqueous iron(II) nitrate.

(i) Predict what would be observed when aqueous methylamine is added to aqueous iron(II) nitrate.

……

……[1]

(ii) Write an ionic equation with state symbols for the reaction in **(d)(i)**.

[2]

(iii) Describe what would be observed if acidified potassium manganate(VII) was added to the solution in **(d)(i)** before the aqueous methylamine was added.

……

……[1]

(iv) State the role of acidified potassium manganate (VII) in the reaction in **(d)(iii)**.

……[1]

[Total: 10]

End of Paper

The Periodic Table of Elements

Group																	
1	2											13	14	15	16	17	18
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9		Key: proton (atomic) number; atomic symbol; name; relative atomic mass									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	3	4	5	6	7	8	9	10	11	12	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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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 –

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).
The Avogadro constant, $L = 6.02 \times 10^{23}\ mol^{-1}$.