EAST SPRING SECONDARY SCHOOL
Towards Excellence and Success

Name: ..... ( )

Class: .....

Preliminary Examination 2021
Secondary 4 Express

CHEMISTRY **6092/01**
Paper 1

14 September 2021 **1 hour**
Tuesday **0800 - 0900**

Additional materials:
OTAS

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, glue or correction fluid.
Write your name and register number in the spaces provided and on the OTAS.

There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate OTAS.

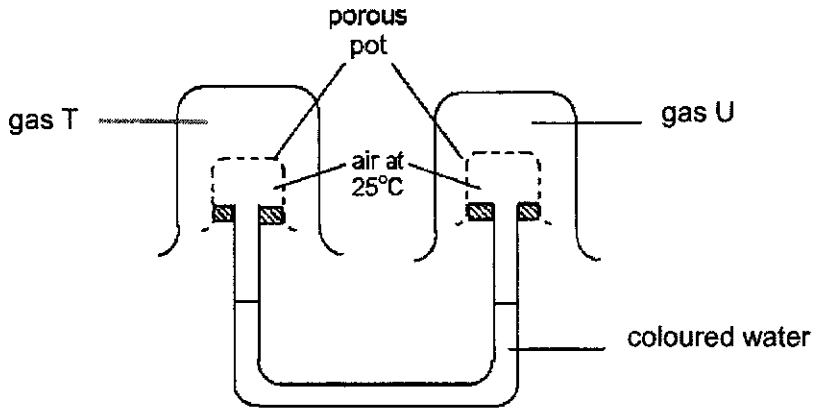
Read the instructions on the OTAS very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this question paper.
A copy of the Periodic Table is printed on page 17.

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

This question paper consists of 17 printed pages including the cover page.

1 The rate of diffusion of two gases, T and U, was investigated using the experimental setup shown below.



Which pair of gases will produce the fastest movement in the water level?

	gas T	gas U
A	H_2	NH_3
B	CO_2	H_2
C	NH_3	H_2
D	CO_2	NH_3

2 A series of tests was carried out on gas A.

test	observations
damp blue litmus paper	turns red
bubbled through acidified silver nitrate	a white precipitate is formed
bubbled through acidified potassium manganate(VII) solution	no visible change is observed

What is gas A?

A ammonia

B carbon monoxide

C hydrogen chloride

D sulfur dioxide

3 A forensic scientist, investigating some paint fragments found near the site of a fatal car accident, suspects that it contains two blue dyes, X and Y.

On crushing the paint and making a chromatogram using ethanol as the solvent, he found a single ring of dye X. When he repeated the process using benzene as solvent, he obtained a single ring of dye Y. However, with acetone as the solvent, two rings of dyes are observed.

Which statement is correct?

A Y is soluble in ethanol but X is not.

B X is soluble in both ethanol and acetone.

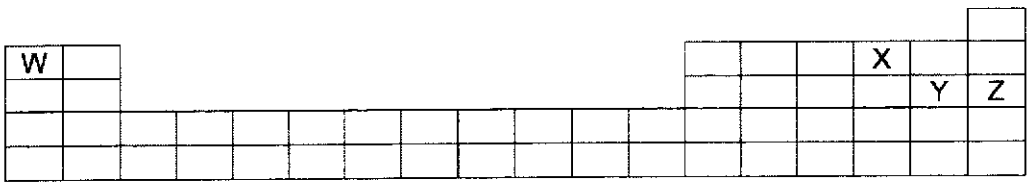
C Y is soluble in benzene but insoluble in acetone.

D X is insoluble in both ethanol and benzene.

4 Which of the following correctly lists the particles with the same number of electrons and the same number of neutrons as $^{20}_{10}Ne$ respectively?

	same number of electrons	same number of neutrons
A	$^{20}_{9}F$	$^{22}_{10}Ne^{+}$
B	$^{22}_{10}Ne^{+}$	$^{23}_{11}Na^{+}$
C	$^{20}_{9}F^{-}$	$^{23}_{11}Na$
D	$^{20}_{9}F^{-}$	$^{19}_{9}F$

5 The positions of the elements W, X, Y and Z are shown in the outline of part of the Periodic Table.



Which statement is correct?

A W is a metal but X, Y and Z are non-metals.

B W and X are solids but Y and Z are gases at room temperature.

C W and X are in the same group while Y and Z are in another group.

D 1 electron is involved in bonding for W and Y, but 2 electrons are involved for X and Z.

6 Rubidium and bromine react together to form the ionic compound rubidium bromide.

Which statement is correct when rubidium bromide is being formed?

A Each atom of rubidium receives an electron from a bromine atom.

B Each atom of rubidium shares a pair of electrons with a bromine atom.

C Each atom of rubidium shares an electron with a bromine atom.

D Each atom of rubidium gives an electron to a bromine atom.

7 The table below shows four different particles.

number of	particle			
	W	X	Y	Z
protons	6	8	8	11
neutrons	6	8	10	12
electrons	6	10	8	10

Which particles will form a covalent compound when chemically combined?

A W and X **B** W and Y **C** X and Y **D** X and Z

8 Which substance could be diamond?

	melting point / °C	boiling point / °C	electrical conductivity when solid
A	–52	–2	poor
B	98	883	good
C	1084	2560	good
D	3550	4830	poor

9 7 g of a gaseous hydrocarbon occupies 6 dm^3 at room temperature and pressure.

What is the relative molecular mass of the hydrocarbon?

A 7

B 24

C 28

D 42

10 The fertilizer, ammonium nitrate (NH_4NO_3, M_r = 80) is manufactured from ammonia (NH_3, M_r = 17) by a two-stage process.

Stage 1: $NH_3 + 2O_2 \rightarrow HNO_3 + H_2O$

Stage 2: $HNO_3 + NH_3 \rightarrow NH_4NO_3$

What is the mass of ammonium nitrate produced from 17 kg of ammonia?

A 40 kg

B 80 kg

C 120 kg

D 160 kg

11 In an electrolysis experiment, the same quantity of electrons deposited 1 mole of copper and 2 mol of metal X. The charge on copper ion was 2+.

What was the charge on the metal X?

A 1+

B 2+

C 3+

D 4+

12 Three electrolytes are listed. Each is electrolysed using inert electrodes.

1 aqueous sodium chloride
2 concentrated hydrochloric acid
3 molten lead(II) bromide

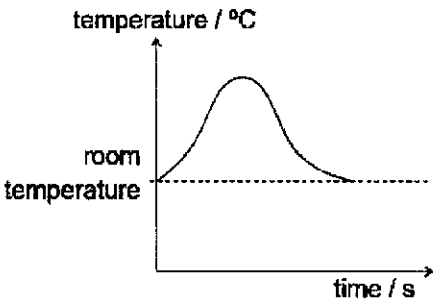
For which electrolyte is a gas formed at both electrodes?

A 2 only **B** 3 only **C** 1 and 2 **D** 1 and 3

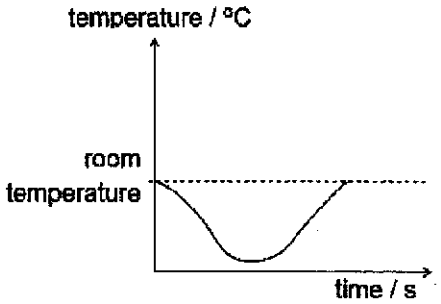
13 The dissolving of ammonium chloride in water is an endothermic process.

Which graph shows how the temperature alters as ammonium chloride is added to water and then the resulting solution is left to stand?

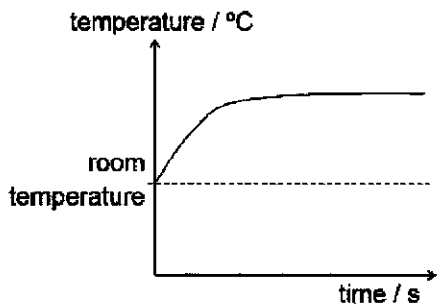
A



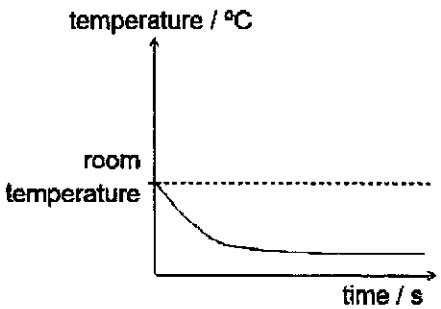
B



C



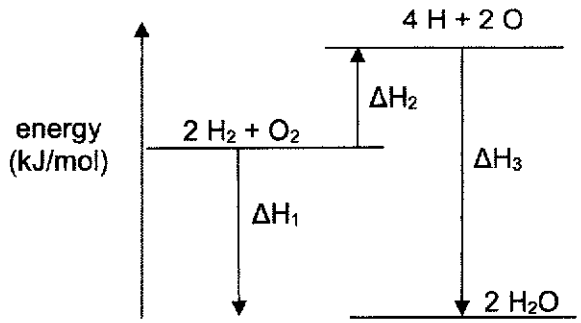
D



14 Hydrogen and oxygen react to form steam as shown in the equation below.

$$2\ H_2(g) + O_2(g) \rightarrow 2\ H_2O\ (g)$$

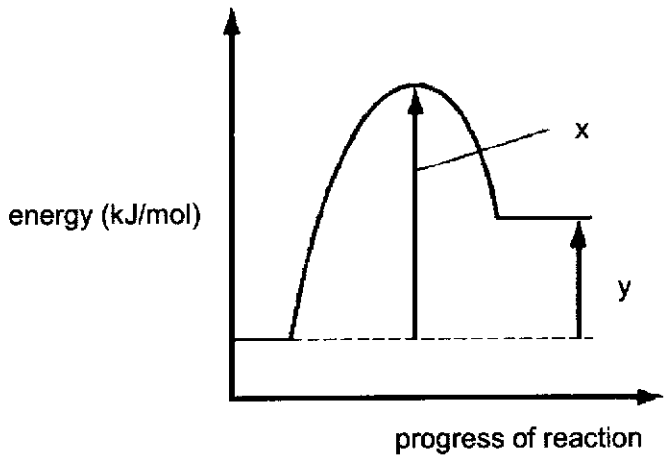
The following energy level diagram represents the reaction between hydrogen and oxygen to form steam:



Which of the following correctly represents the energy change for bond breaking and bond formation?

	bond breaking	bond formation
A	ΔH_1	ΔH_2
B	ΔH_2	ΔH_3
C	ΔH_2	ΔH_1
D	ΔH_1	ΔH_3

15 The energy profile diagram for a chemical reaction is shown below.



Which statement about the energy profile diagram is correct?

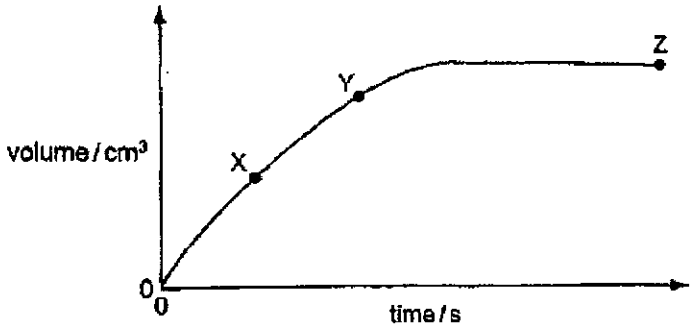
A The overall enthalpy change is equal to x + y.

B The reaction is exothermic.

C The value of x would decrease in the presence of catalyst.

D The value of y would increase in the presence of catalyst.

16 The graph shows how the volume of hydrogen gas produced by the reaction between 25 cm^3 of 1.0 mol/dm^3 hydrochloric acid and an excess of magnesium varied with time.



Which statement is correct?

A The reaction is faster at point Y than point X.

B All the magnesium has reacted at point Z.

C The volume of gas produced is doubled if 50 cm^3 of 1 mol/dm^3 of acid is used.

D The rate of reaction is the highest at point Z.

17 The reaction between copper and concentrated nitric acid is shown below.

$$Cu + 4HNO_3 \rightarrow Cu(NO_3)_2 + 2H_2O + 2NO_2$$

Which statement about this reaction is correct?

A Nitric acid is a reducing agent.

B Nitrogen is oxidised as it loses 1 oxygen atom.

C Copper is oxidised as it loses 2 electrons.

D The oxidation state of oxygen has changed.

18 The oxide of titanium, TiO_2, is used as a 'whitener' in toothpaste. It is obtained from the ore iron(II) titanate, $FeTiO_3$.

What is the oxidation state of Ti in iron(II) titanate, $FeTiO_3$?

A +1

B +2

C +3

D +4

19 Some statements about sulfuric acid are given.

1 A white precipitate is formed when aqueous barium nitrate is added.
2 The solution turns anhydrous copper(II) sulfate from white to blue.
3 The addition of Universal Indicator shows that the solution has a pH value of less than 7.0.
4 The solution reacts with copper(II) oxide, forming a blue solution.

Which two statements confirm the acidic nature of the solution?

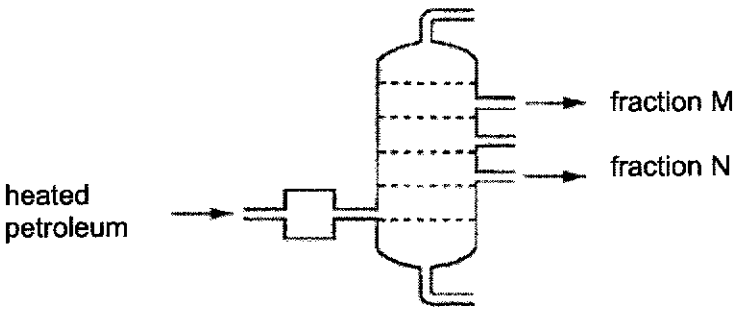
A 1 and 2

B 1 and 3

C 2 and 4

D 3 and 4

20 The diagram shows the fractional distillation of petroleum.



Which row about fraction M and N are correct?

	M burns more easily than N	M has a higher boiling point than N	M is more viscous than N
A	true	false	false
B	true	true	false
C	false	true	true
D	false	false	true

21 A student has five reagents.

- dilute hydrochloric acid
- dilute sulfuric acid
- dilute nitric acid
- solid calcium carbonate
- solid copper(II) carbonate

How many soluble salts can be prepared from these reagents?

A 3

B 4

C 5

D 6

22 X, Y and Z are elements in the third period of the Periodic Table.

The oxide of X, Y and Z are basic, amphoteric, and acidic respectively.

Which of the following correctly show X, Y and Z?

	X	Y	Z
A	Mg	Al	S
B	Ca	Zn	Se
C	Be	Al	N
D	Ca	Se	Zn

23 Which statement is correct about the elements in Group I of the Periodic Table?

A They are equally reactive.

B They occur uncombined in nature.

C They form chlorides of similar formulae.

D They become less metallic as the relative proton(atomic) number increases.

24 Element R has the following properties.

- low melting and boiling point
- forms ionic compound when react with sodium
- has coloured vapour

Which part of the Periodic Table does R belong to?

A Group I

B Group II

C Group VII

D transition elements

25 Which element is least likely to form an oxide?

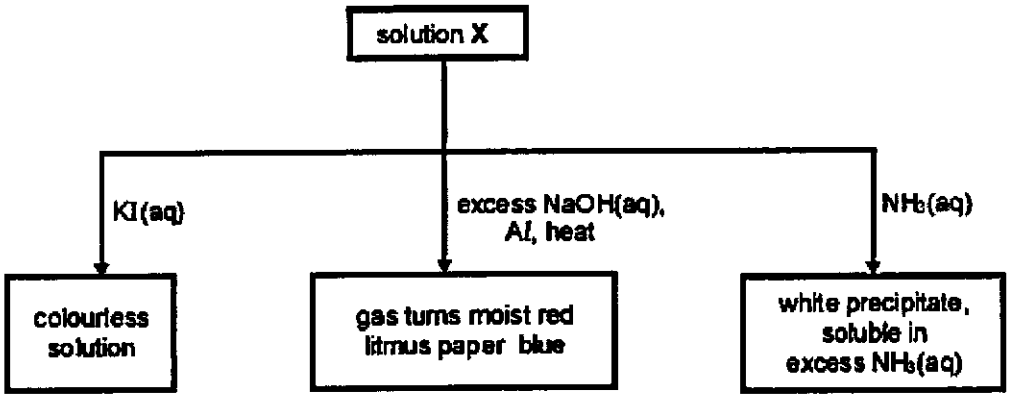
A sodium

B iron

C carbon

D neon

26 The diagram below shows the reactions of solution X.



What are the ions present in solution X?

A zinc ions and nitrate ions

B lead(II) ions and nitrate ions

C ammonium ions and chloride ions

D aluminium ions and nitrate ions

27 The first member of a homologous series is C_6H_6.

What is the formula of the next member?

A C_7H_7

B C_7H_8

C C_8H_7

D C_8H_8

28 Which statement is **not** correct for all metals?

A They are good conductors of electricity.

B They lose electrons to form positive ions.

C They have high melting and boiling points.

D They are good conductors of heat.

29 Which pair of elements cannot be used to form an alloy?

A copper and zinc

B magnesium and aluminium

C iron and carbon

D sodium and oxygen

30 Hydrogen is produced by the reaction of a metal A and a dilute acid B.
When the same gas is passed over an oxide of metal C, it reduced the metal oxide to its metal in the presence of heat.

Which row of substances would give these results?

	metal A	dilute acid B	metal C oxide
1	calcium	hydrochloric acid	lead(II) oxide
2	copper	hydrochloric acid	silver oxide
3	iron	sulfuric acid	copper(II) oxide
4	zinc	sulfuric acid	calcium oxide

A 1 and 3 only

B 1 and 4 only

C 2 and 3 only

D 2 and 4 only

31 Which pair of substances is correct?

	substance added to blast furnace	main impurity in the iron ore
A	calcium oxide	iron(III) oxide
B	coke	sand
C	limestone	carbon
D	iron(III) oxide	coke

32 1 g of four different metals are reacted with excess sulfuric acid separately.

Which metal will produce the greatest volume of gas upon completion of the reaction?

A magnesium

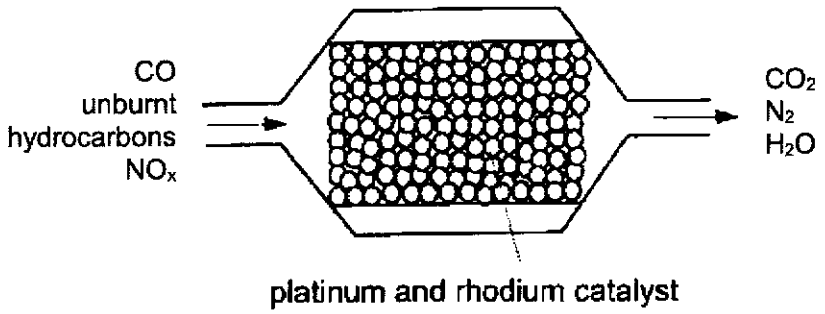
B iron

C zinc

D copper

33 The diagram below shows a section of a catalytic converter in the exhaust system of a car.

The harmful gases are converted into carbon dioxide, nitrogen and water vapour.



Which reactions take place in this catalytic converter?

I Platinum and rhodium catalyse redox reactions.
II Carbon monoxide and unburnt hydrocarbons react together.
III Carbon monoxide and oxides of nitrogen react together.

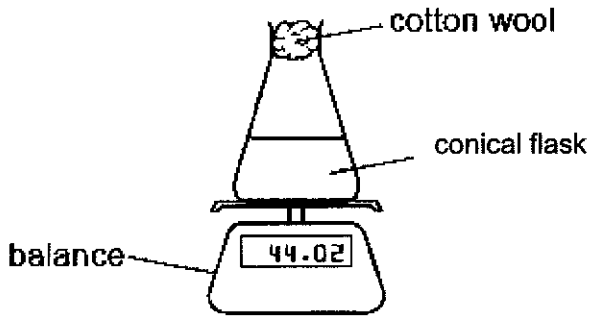
A I and II only

B II and III only

C I and III only

D I, II and III

34 The diagram below shows an experimental set-up used to determine the rate of reaction.



Which of the following reaction is **not** suitable for using the above experimental set-up to determine the rate of reaction?

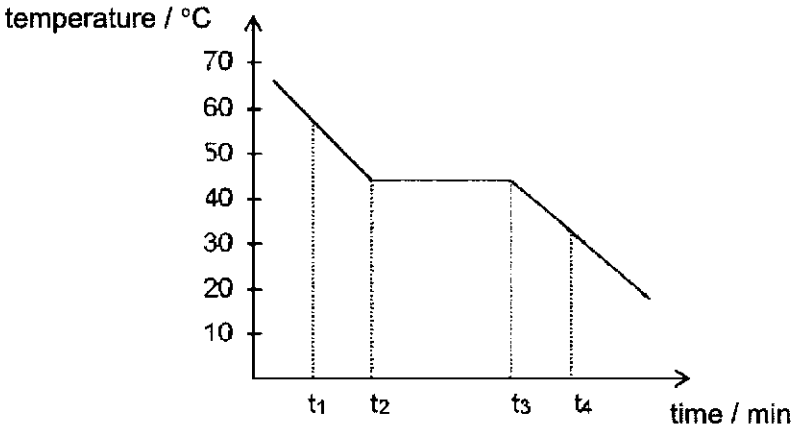
A $CaCO_3 + 2HNO_3 \rightarrow Ca(NO_3)_2 + CO_2 + H_2O$

B $Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$

C $AgNO_3 + HCl \rightarrow AgCl + HNO_3$

D $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

35 Stearic acid is a solid at room temperature. The cooling curve of stearic acid is as shown.



Which statement can be inferred from the graph?

A At time interval t_1 to t_2, heat is absorbed from the surroundings.

B At time interval t_2 to t_3, all stearic acid exists as solid.

C At time interval t_2 to t_3, crystals of stearic acid start to form.

D At time interval t_3 to t_4, all the stearic acid molecules are irregularly arranged.

36 To reduce atmospheric pollution, the following gases from a coal-burning power station are treated with powdered calcium carbonate.

1 carbon monoxide, CO
2 nitrogen dioxide, NO_2
3 sulfur dioxide, SO_2

Which gases can be removed by the powdered calcium carbonate?

A 1 and 2

B 1 and 3

C 2 and 3

D 1, 2 and 3

37 Buffer solutions are mixtures that contain either

- a weak acid and its salt, or
- a weak base and its salt.

Which of the following pair of solutions can be used to prepare a buffer solution?

A NaOH and $MgCl_2$

B HNO_3 and $NaNO_3$

C NH_4OH and NH_4NO_3

D HCl and NH_4Cl

38 In the polymerisation of ethene to form poly(ethene), which does **not** change?

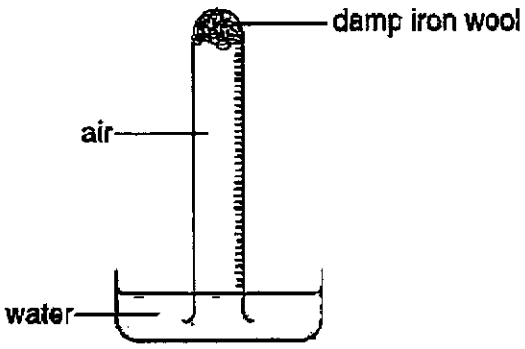
A boiling point

B density

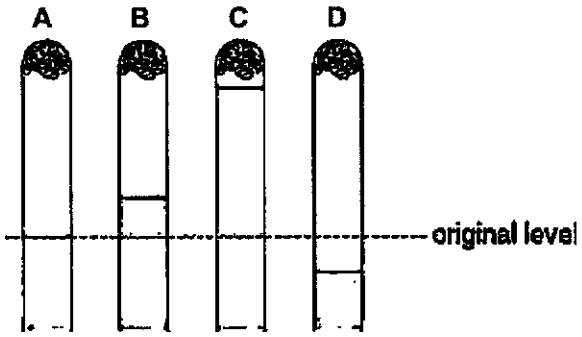
C empirical formula

D molecular mass

39 The apparatus shown is set up and left for a week.



Where would the water level be at the end of the week?



40 Which of the following contains salts that are best prepared by titration?

A copper(II) chloride, potassium nitrate, silver sulfate

B magnesium chloride, silver chloride, lithium sulfate

C sodium chloride, ammonium nitrate, potassium sulfate

D sodium chloride, copper(II) nitrate, barium sulfate

~ End of Paper ~

The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 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 –		

Key: atomic number / atomic symbol / name / relative atomic mass

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.)

East Spring Secondary School

Towards Excellence and Success

Name: ..... ( )

Class: .....

Preliminary Examination 2021
Secondary 4 Express

Chemistry
Paper 2

6092/2

Monday
30 August 2021

1 hour 45 minutes
0800 - 0945

READ THESE INSTRUCTIONS FIRST

Write your name, class and register 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 in the spaces provided.

Section B
Answer all **three** questions. The last question in the form either/or.
Answer all questions 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 21.

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

Section	Marks
Section A	50
Section B	30
Total	80

This question paper consists of 21 printed pages including the cover page.

Section A [50 marks]
Answer **all** questions in this section in the spaces provided.

A1 The equations A, B, C, D, E F, G and H shows various chemical reactions.

A: $CH_4 + O_2 \rightarrow CO_2 + H_2O$

B: $2KI + Cl_2 \rightarrow 2KCl + I_2$

C: $2HCl + CaO \rightarrow CaCl_2 + H_2O$

D: $2Na + CuCl_2 \rightarrow 2NaCl + Cu$

E: $Ba(NO_3)_2 + H_2SO_4 \rightarrow BaSO_4 + 2HNO_3$

F: $C_{20}H_{42} \rightarrow C_4H_{10} + C_{16}H_{32}$

G: $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

H: $C_2H_4 + H_2 \rightarrow C_2H_6$

Use the letters A, B, C, D, E, F, G and H to answer the following questions.

(a) **(i)** Which equation shows neutralisation? .....

(ii) Which equation shows addition? .....

(iii) Which equation shows cracking? .....

(iv) Which equation shows combustion? .....

(v) Which equation shows displacement? .....

(vi) Which equation shows precipitation? ..... [6]

(b) Iron is a transition metal produced from the reaction in equation G.

Which of these statements about transition metals are **true** and which are **false**?

Put a tick (√) in one box in each row.

	true	**false**
They form coloured compounds.		
They form compounds with only one oxidation state.		
They have low melting and boiling point.		
They conduct electricity.		

[2]

[Total: 8]

A2 Table 2.1 shows some potassium oxyhalides and their thermal decomposition temperatures.

Table 2.1

potassium oxyhalide	formula	thermal decomposition temperature[1]
potassium chlorate	K_3ClO	above 400 °C
potassium bromate	K_3BrO	at 370 °C
potassium iodate		above 100 °C

[1] source from https://pubchem.ncbi.nlm.nih.gov/

(a) **(i)** Complete Table 2.1 to show the chemical formula of potassium iodate. [1]

(ii) What conclusion can you make from Table 2.1 about the relationship between reactivity of the halogen and the thermal decomposition temperature of the potassium oxyhalides?

.....

.....

..... [1]

(b) An aqueous solution of potassium chlorate is a good oxidising agent.

Describe a chemical test to confirm the oxidising properties of potassium chlorate and state the result.

test: .....

result: ..... [2]

(c) When potassium chlorate reacts as an oxidising agent, the chlorate ions are reduced to chloride ions, as shown in the equation below.

$$ClO_3^- + 6\,H^+ + 6\,e^- \rightarrow Cl^- + 3\,H_2O$$

Use ideas about oxidation state to explain why the chlorate ion, ClO_3^- is reduced.

.....

.....

..... [2]

[Total: 6]

A3 Methyl methacrylate (MMA) is an ingredient used widely in the preparation of artificial acrylic nails. It is a volatile liquid that has been described as fragrant and fruity.

Fig. 3.1 shows the structural formula of MMA.

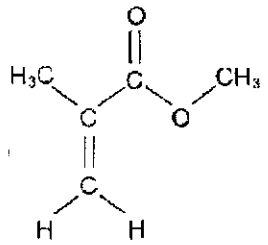


Fig. 3.1

(a) Name the functional group that is responsible for the fragrant and fruity smell.

..... [1]

(b) Draw the full structural formulae of the two organic compounds that are used to make MMA.

[2]

(c) Methyl methacrylate can undergo addition polymerisation to form plastic, that has high optical clarity, high transparency, and UV stability.

(i) Describe two differences between addition polymerisation and condensation polymerisation.

.....

.....

.....

..... [2]

(ii) Name the polymer.

..... [1]

(iii) Draw part of the structure of the polymer containing three repeating units.

[1]

[Total:7]

A4 Fig. 4.1 shows some of the processes in the carbon cycle.

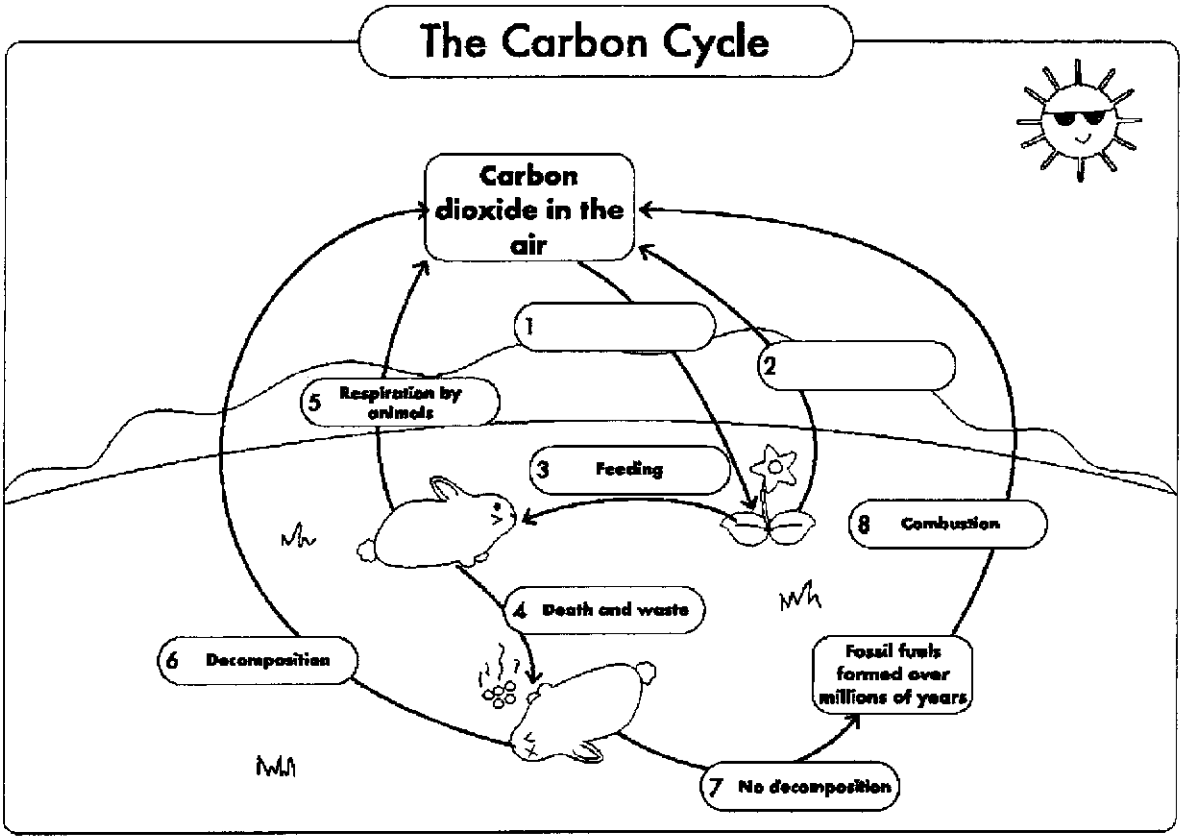


Fig. 4.1

(a) **(i)** Complete Fig. 4.1 by naming process 1 and process 2.

process 1: ..... process 2: ..... [2]

(ii) Describe, with the help of chemical equations, how the amount of carbon dioxide is regulated in the atmosphere through process 1 and process 2?

.....

.....

.....

.....

.....

..... [3]

(b) When fossil fuels undergo combustion, it increases the amount of carbon dioxide in the air.

Suggest an alternative source of clean fuel to replace fossil fuel.

Explain your reasoning.

.....

..... [2]

[Total:7]

A5 The following are 2 isomers of an alcohol, **X** and **Y**.

$CH_3 - CH_2 - CH_2 - CH_2 - OH$ **X**

$(CH_3)_2 CH - CH_2 - OH$ **Y**

(a) **(i)** Define *isomer*.

.....

..... [1]

(ii) Name isomer **X**.

..... [1]

(b) Draw the full structural formula for isomer **Y**.

[1]

(c) Isomer **X** can be manufactured in the lab from an alkene.

(i) State the conditions needed to make isomer **X** from alkene.

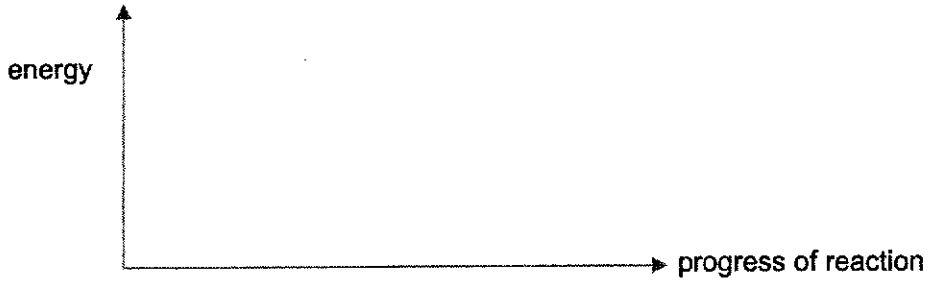
.....

..... [2]

(ii) Name the alkene that can be used to make isomer **X**.

..... [1]

(iii) The reaction is exothermic. Draw a labelled energy profile diagram of this reaction, indicating the activation energy and enthalpy change.



[3]

[Total:9]

A6 To prepare a pure sample of magnesium nitrate salt, a student carried out a reaction using magnesium carbonate powder and dilute nitric acid as shown in the equation below.

$$MgCO_3 + 2HNO_3 \rightarrow Mg(NO_3)_2 + CO_2 + H_2O$$

The student wants to obtain 20 g of pure magnesium nitrate crystals, $Mg(NO_3)_2 \cdot 6H_2O$, at the end of the experiment.

(a) The student needs to add excess magnesium carbonate to the dilute nitric acid.

Explain why excess magnesium carbonate was added.

.....

..... [1]

(b) Briefly state the steps required to obtain pure magnesium nitrate crystals after excess magnesium carbonate is added to nitric acid.

.....

.....

.....

.....

.....

.....

..... [3]

(c) The percentage yield for this method of salt preparation is typically around 80% to 90%.

The student manged to obtain 80% yield for his experiment.

(i) Calculate the theoretical mass of magnesium nitrate crystals he needs to produce 20 g of the crystals,

theoretical mass of magnesium nitrate crystals: ..... g [1]

(ii) Calculate the volume of 1 mol/dm^3 nitric acid needed to produce 20 g of pure magnesium nitrate crystal.

[M_r of $Mg(NO_3)_2 \cdot 6H_2O$: 256]

volume of nitric acid needed= ..... dm^3 [3]

[Total: 8]

A7 Fig. 7.1 shows two important industrial processes that produce substances used as starting reactants, for many other reactions used to manufacture compounds found in agricultural materials and explosives.

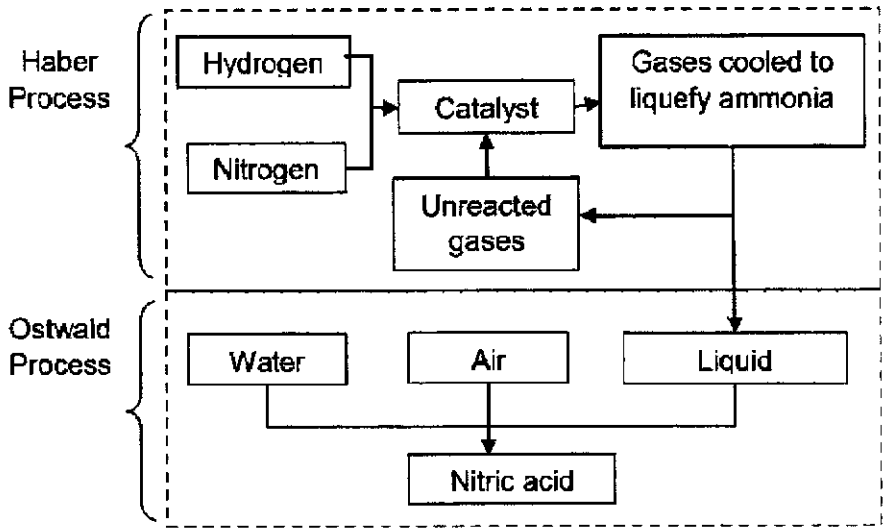


Fig. 7.1

(a) State the source of each gas used in the Haber Process.

hydrogen: .....

nitrogen: ..... [2]

(b) State the conditions required for Haber process.

.....

..... [1]

(c) Suggest why air is not used as a raw material in the Haber Process.

.....

..... [1]

(d) When the products of Haber and Ostwald processes react together, a new compound is formed.

Suggest one use of the compound.

..... [1]

[Total: 5]

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.

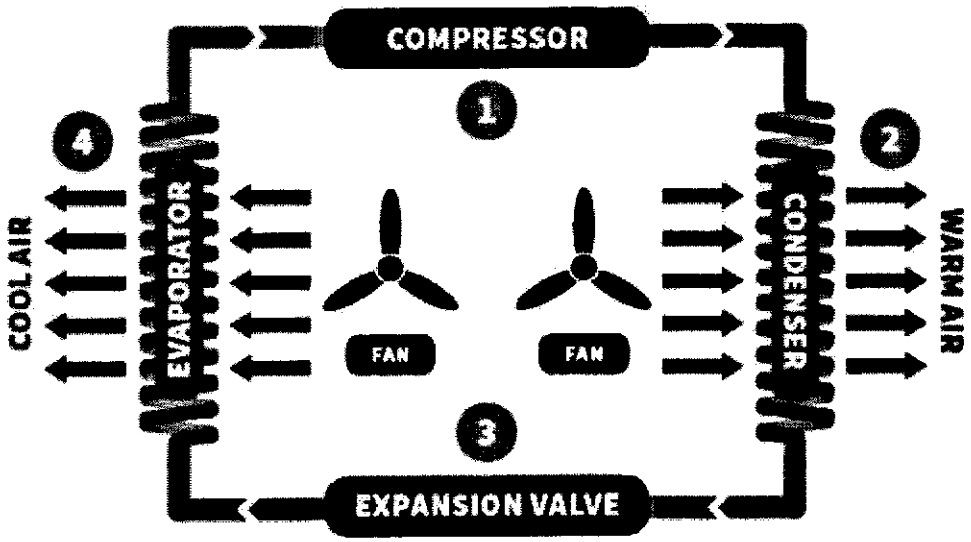
B8 How an air-conditioner system works in a home

Air-Conditioner

Air conditioners contain a refrigerant inside copper coils. As the refrigerant absorbs heat from the indoor air, it changes from a low-pressure gas to a high-pressure vapour in the compressor. The air conditioning components then send the refrigerant outside where a fan blows hot air over the coils and expels it to the exterior of the air-conditioner system.

The refrigerant is then expelled through expansion valves to be cooled down and turns back into a low-pressure gas. Another fan located inside the home blows air over the cool coils to distribute the resulting cold air throughout the home.

Fig. 8.1 shows how the refrigerant moves through the four components (compressor, condenser, expansion valve and evaporator) in an air conditioner system to produce cool air.



source: CEN.ACS.ORG Aug 14/21,2017

Fig. 8.1

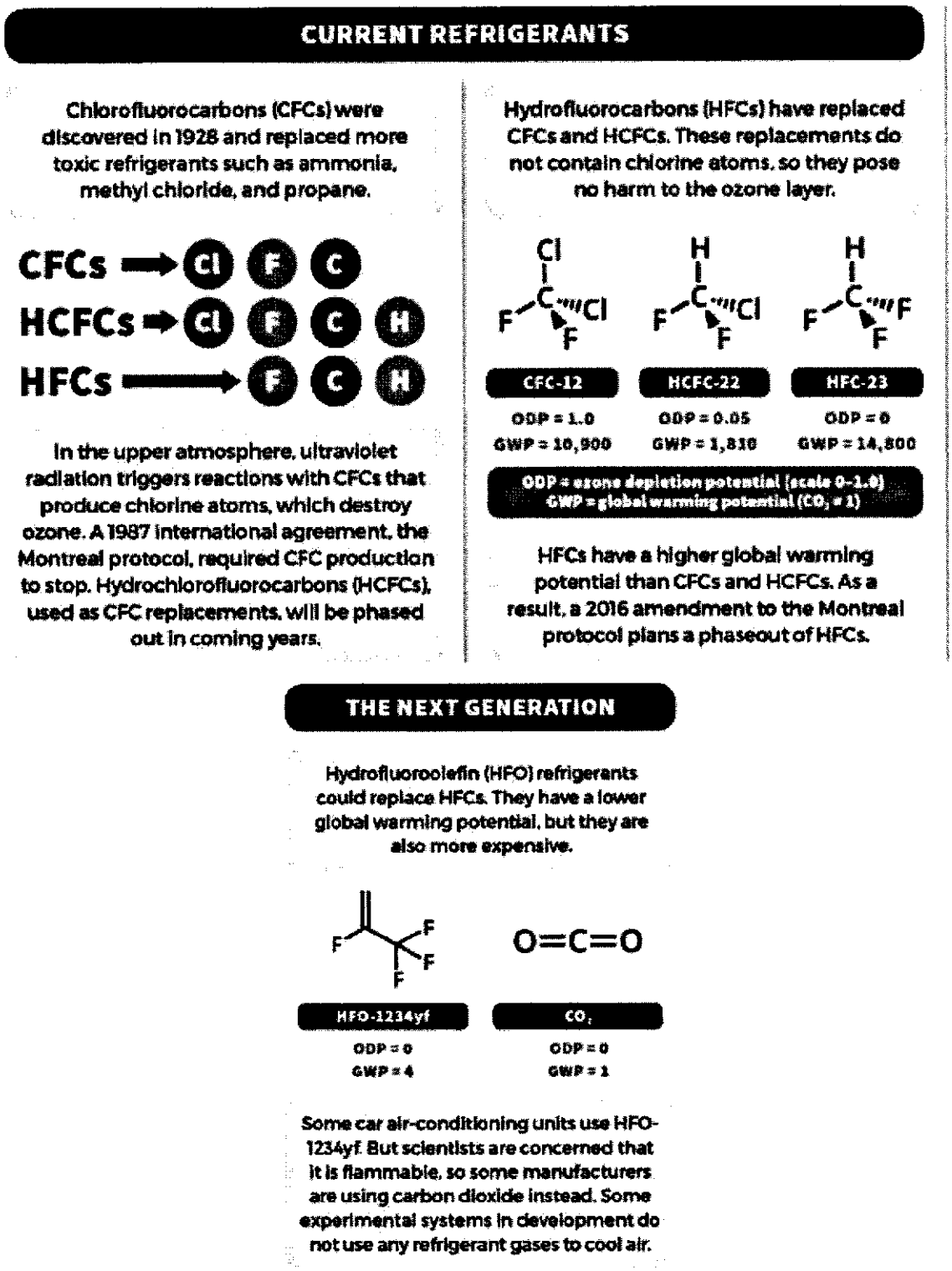
Refrigerants

A refrigerant is a compound typically found in either a liquid or gaseous state. It readily absorbs heat from the environment and can provide refrigeration or air conditioning when combined with other components such as compressors and evaporators.

Refrigerant play an important role in air conditioning, refrigeration, and freezing technology.

Despite their important role, refrigerants have been known to cause air pollution, and scientists have been working on greener options to replace refrigerants.

Fig. 8.2 shows the different refrigerants used and possible replacements.



source: CEN.ACS.ORG Aug 14/21,2017

Fig. 8.2

(a) With reference to Fig. 8.1, complete the table below.

component	process
compressor	Refrigerant vapour gets pressurized and increased in its temperature.
	The cold mist travel through coils. Air blown over the coils gets cooled. Heat from the air vaporise the refrigerant.
	The liquid refrigerant is forced through this component. This turns the liquid into a mist and rapidly cools it.
	The hot high-pressure vapour moves through coils and lose heat which gets vented outside by a fan.

[2]

(b) Describe the change in movement and arrangement of refrigerant particles in the compressor.

.....

..... [2]

(c) In the upper atmosphere, ultraviolet rays trigger the hydrochlorofluorocarbon, HCFC-22, found in refrigerants, to produce chlorine atoms

The chlorine atoms produced from HCFC-22 then destroy the ozone layer in several equations as shown below.

$$CHF_2Cl \rightarrow CHF_2 + Cl$$
$$Cl + O_3 \rightarrow ClO + O_2$$
$$ClO + O_3 \rightarrow 2O_2 + Cl$$

Use the above equations to write an overall equation for the reaction.

..... [1]

(d) HFC-23 is a powerful greenhouse gas that can be produced from methane.

(i) Draw a dot-and-cross diagram to show the bonding in HFC-23.
Show all electrons.

[2]

(ii) Describe how HFC-23 may be produced from methane.

.....

..... [2]

.....

(e) During the 3rd International Symposium on Engineering and Earth Sciences held last year, a perfect refrigerant is defined to be environmentally friendly with zero Ozone Depletion Potential (ODP) and low Global Warming Potential (GWP). It should also be non-toxic and non-flammable.

Using data from Fig. 8.2, suggest a perfect refrigerant that can be used.

Explain your reasoning.

.....

.....

..... [3]

[Total: 12]

B9 Fig. 9.1 shows the experimental set-up for the electrolysis of concentrated aqueous sodium chloride. A few drops of Universal Indicator is added to the sodium chloride solution before the start of the experiment.

The actual electric cell used in the this set-up is shown in Diagram B.

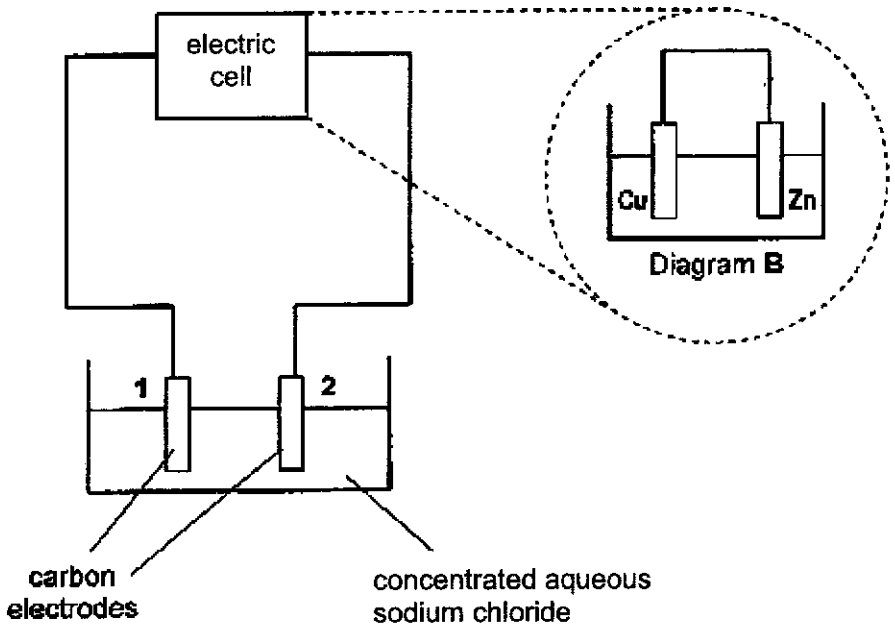


Fig. 9.1

(a) Write the ionic half equations for the reaction that happens at cathode and anode during electrolysis of concentrated aqueous sodium chloride.

cathode:.....

anode:..... [2]

(b) As the electrolysis proceeds, some changes are observed in the concentrated aqueous sodium chloride.

State the changes observed.

Explain why the changes were observed.

.....

.....

.....

..... [2]

(c) **(i)** Show the direction of electron flow in Diagram B of Fig. 9.1. [1]

(ii) With reference to your answer in **(c)(i)**, which of the carbon electrodes, 1 or 2, used in the experiment is the anode?

..... [1]

(d) The electrolyte in the electric cell as shown in Diagram B is aqueous copper(II) sulfate solution.

(i) Describe the observation at copper electrode in Diagram B.

.....

..... [1]

(ii) Suggest how the voltage for this electrolysis experiment can be increased.

.....

..... [1]

[Total:8]

EITHER

B10 In the early 19th century, a chemist, Frederich Wöhler, isolated aluminium metal by reacting potassium with aluminium chloride at high temperature as shown below.

$$3K + AlCl_3 \rightarrow 3KCl + Al$$

(a) Would the enthalpy change for the reaction be positive or negative?

Explain your answer.

.....

..... [2]

(b) Suggest why it was essential that Frederich Wöhler kept water away from his reacting chemicals.

.....

..... [1]

(c) Explain why he used the dangerous and expensive potassium to prepare aluminium rather than the safe and cheaper copper.

.....

.....

..... [2]

(d) A modern scientist recommended performing Frederich Wöhler's experiment in an atmosphere filled with inert argon.

Explain, with reference to electronic structure, why argon can provide an inert environment for the reaction.

.....

..... [1]

(e) After the successful isolation of aluminium by Frederich Wöhler, aluminium was widely used to manufacture other useful substances such as Magnox. Magnox is used in nuclear reactors.

The aluminium atoms in Magnox form a metallic structure with magnesium. Fig. 10.1 represents a simple illustration of the bonding in Magnox.

(i) Use your knowledge of atomic structure and metallic bonding to label the boxes.

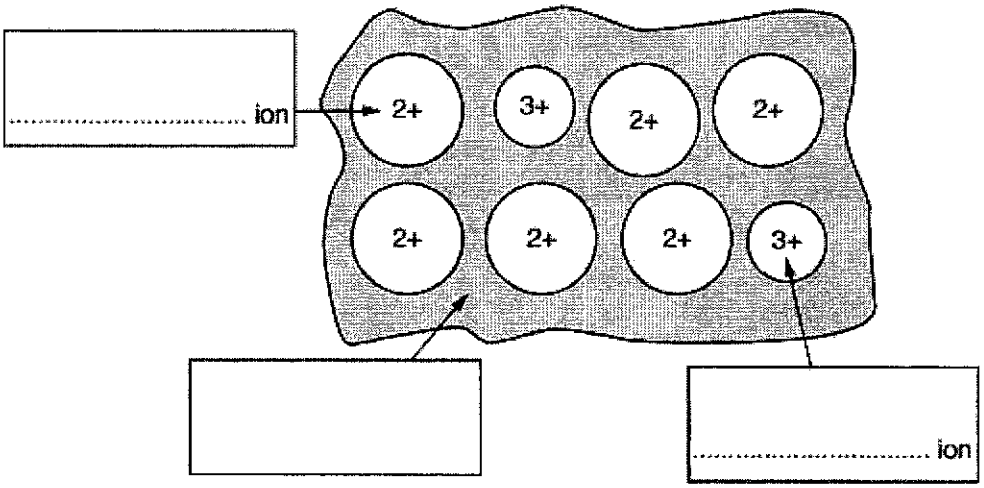


Fig. 10.1

[2]

(ii) Explain why Magnox is harder than pure magnesium.

.....

.....

..... [2]

[Total: 10]

OR

B10 A student carried out some experiments to investigate the reactivity of four metals, iron, X, calcium and Y.

Tables 10.1 and 10.2 show the results of the experiments.

Table 10.1

metal	iron	X	calcium	Y
observations when metal is added to aqueous iron(II) nitrate	no visible reaction	iron is deposited, no gas evolved	iron is deposited and a gas is evolved	no visible reaction

Table 10.2

metal oxides	Fe_2O_3	XO	CaO	Y_2O
observation when metal oxide is heated strongly	no visible reaction	no visible reaction	no visible reaction	metal Y is formed

(a) What is the order of reactivity for the four metals, X, Y, iron, and calcium?

most reactive .....

.....

.....

least reactive ..... [1]

(b) Write an ionic equation for the reaction when metal X is added to aqueous iron(II) nitrate.

..... [1]

(c) When calcium is placed in a beaker of aqueous iron(II) nitrate, iron is deposited and a gas is evolved.

(i) Name the gas evolved in this reaction.

..... [1]

(ii) Explain how the gas named in **(c)(i)** is formed when calcium is added to aqueous iron(II) nitrate.

.....

..... [1]

(d) Suggest the identity of metal X and explain your answer.

identity: .....

explanation: .....

..... [3]

(e) Metal Y oxide has a formula Y_2O. It has another oxide with the formula of Y_4O_4. Its oxides are coloured. Y is often used as a catalyst in a few reactions.

(i) State the oxidation state of Y in Y_2O.

..... [1]

(ii) Suggest the identity of Y and explain your answer.

.....

.....

..... [2]

[Total: 10]

The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 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 –		

Key: atomic number / atomic symbol / name / relative atomic mass

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.)

East Spring Secondary School
Science Department
Secondary 4E Pure Chemistry Marking Scheme
Preliminary Examination 2021

Paper 1 - Multiple Choice Questions (40 x 1mark)

1	B	11	A	21	C	31	B
2	C	12	C	22	A	32	A
3	B	13	B	23	C	33	C
4	D	14	B	24	C	34	C
5	A	15	C	25	D	35	C
6	D	16	C	26	A	36	C
7	B	17	C	27	-	37	C
8	D	18	D	28	C	38	-
9	C	19	D	29	D	39	B
10	A	20	-	30	A	40	C

East Spring Secondary School
Science Department
Secondary 4E Pure Chemistry Marking Scheme
Preliminary Examination 2021

A1 The following show eight chemical reactions.

A: $CH_4 + O_2 \rightarrow CO_2 + H_2O$

B: $2KI + Cl_2 \rightarrow 2KCl + I_2$

C: $2HCl + CaO \rightarrow CaCl_2 + H_2O$

D: $2Na + CuCl_2 \rightarrow 2NaCl + Cu$

E: $Ba(NO_3)_2 + H_2SO_4 \rightarrow BaSO_4 + 2HNO_3$

F: $C_{20}H_{42} \rightarrow C_4H_{10} + C_{16}H_{32}$

G: $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

H: $C_2H_4 + H_2 \rightarrow C_2H_6$

Which reaction is

(a) **(i)** Which equation shows neutralisation? C

~~**(ii)** Which equation shows addition?~~ H

~~**(iii)** Which equation shows cracking?~~ F

(iv) Which equation shows combustion? A

(v) Which equation shows displacement? B or D [1] each

(vi) Which equation shows precipitation? E

(b) Which states about transition metals are **true** and which are **false**?

Put a tick (√) in one box in each row.

	true	false
They form coloured compound.	√	
They only have one oxidation state.		√
They have low melting and boiling point.		√
They conduct electricity.	√	

1c-3c [1]
4c [2]

A2 The table show some potassium oxyhalide and the temperature they undergo thermal decomposition.

potassium oxyhalide	formula	thermal decomposition temperature [1]
potassium chlorate	K_3ClO	above 400 °C
potassium bromate	K_3BrO	at 370 °C
potassium iodate	K_3IO	above 100 °C

[1] source from https://pubchem.ncbi.nlm.nih.gov/

(a) (i) Complete the table above with the chemical formula of potassium iodate. [1]

(ii) What conclusion can you make from the table about the relationship between reactivity of halogen and the temperature the potassium oxyhalide decompose on heating?

The less reactive the halogen, the lower is the thermal decomposition temperature. [1]

accept any other reasonable conclusion

(b) An aqueous solution of potassium chlorate(V) is a good oxidising agent.

Describe a chemical test to confirm the oxidising properties of potassium chlorate(V) and state the result.

test: Add aqueous potassium iodide / KI to a solution to potassium chlorate(V).

result:colourless solution turns brown solution [2]

(c) When potassium chlorate(V) reacts as an oxidising agent, the chlorate(V) ions are reduced to chloride ions.

$$ClO_3^- + 6\,H^+ + 6\,e^- \rightarrow Cl^- + 3\,H_2O$$

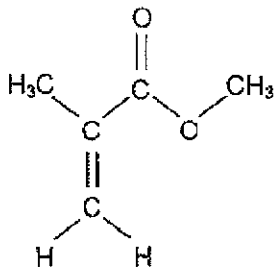
Explain, in terms of oxidation state, why the chlorate(V) ion, ClO_3^- is reduced.

Chlorine in chlorate(V) is reduced because oxidation state of chlorine decrease [1] from +5 in ClO_3^- to -1 in Cl^- [1]

[2]

A3 Methyl methacrylate (MMA) is an ingredient used widely in the preparation of artificial acrylic nails. It is a volatile liquid that has been described as fragrant and fruity.

The structural formula of MMA is



(a) Name the functional group that is responsible for the fragrant and fruity smell.

ester [1]

(b) Draw the full structural formulae of the two organic compounds that are used to make MMA.

[2]

(c) Methyl methacrylate can undergo addition polymerisation to form plastic, that has high optical clarity, high transparency, and UV stability.

(i) Describe two differences between addition polymerisation and condensation polymerisation.

addition polymerisation involves alkene / one functional group but condensation polymerisation involves 2 different functional groups [1]

addition polymerisation does not lose any atom or molecule during formation but condensation polymerisation will eliminate/lose a small molecule like water or hydrogen chloride for example. [1] [2]

(ii) Name the polymer.

poly(methyl methacrylate) / polymethyl methacrylate [1] [1]

(iii) Draw part of the structure of the polymer containing three repeating unit.

(iv) Suggest a use for this polymer.

contact lens, glaze, window, lamp fixture, shield, acrylic sheet, denture, aquarium, [1]

accept any suitable answer in line with the properties and commercial usage [1]

(v) A sample of the polymer was analysed and found to have an average relative molecular mass of 25 200.

What is the number of monomer units that are used to form the polymer?

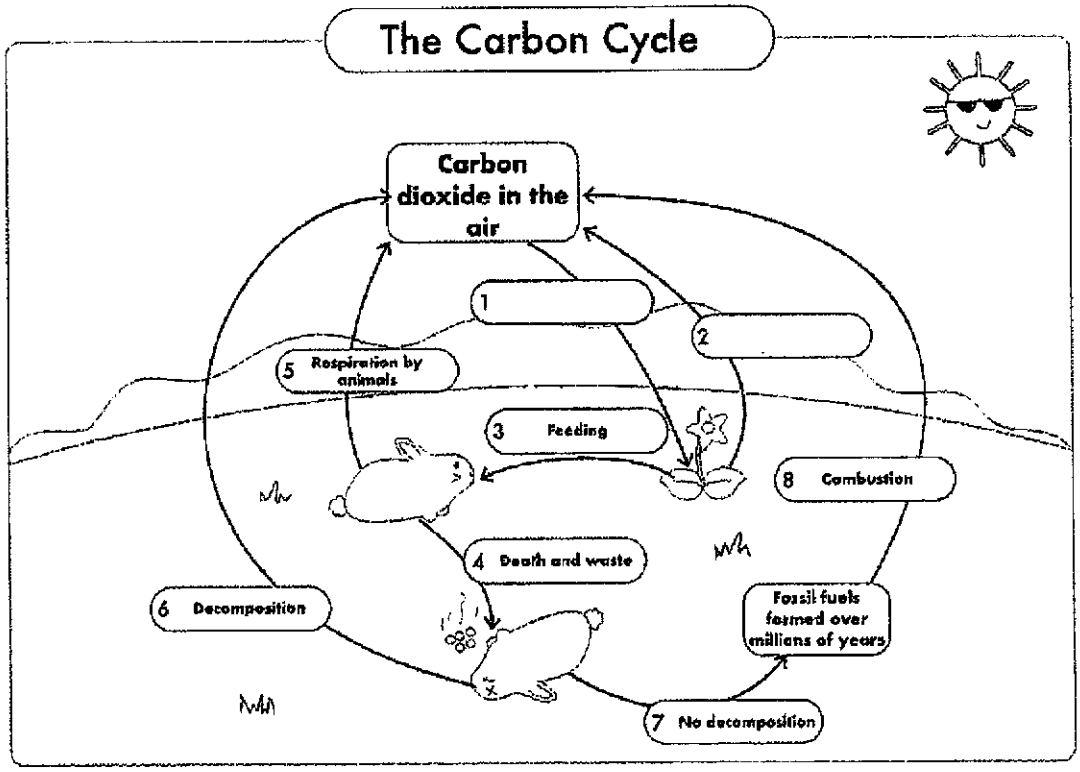
Mr of Methyl methacrylate: 5(12) + 8 + 2(16) =100

number of monomer: 25200/100 = 252

[2]

[Total: 10]

A4 The diagram shows the possible processes in the carbon cycle.



(a) **(i)** Complete the diagram above by stating the process 1 and process 2.
process 1: photosynthesis process 1: respiration [2]

(ii) Describe, with the help of chemical equations, how carbon dioxide is regulated in the atmosphere by the carbon cycle by process 1 and process 2?
$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ [1]

$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$ [1]

Process 2/ respiration increase / add the carbon dioxide in the atmosphere

Process 1 /photosynthesis remove carbon dioxide from the atmosphere
[3]

This cycle continues to regulate the amount of carbon dioxide in the atmosphere

(b) When fossil fuel undergo combustion, it increases the carbon dioxide in the air.

Name an alternative source of clean fuel to replace fossil fuel and support with reason.
hydrogen / electricity / fuel cell / geothermal / hydroelectricity / nuclear energy / wind energy
$H_2 + O_2 \rightarrow H_2O$
When hydrogen burns, it produces on water only, no carbon dioxide is produced so it is an alternative source of clean fuel. / Does not produce any harmful substance. [1]

~~A5~~ The following are 2 isomers of an alcohol, **X** and **Y**.

$CH_3 - CH_2 - CH_2 - CH_2 - OH$ **X**

$(CH_3)_2 CH - CH_2 - OH$ **Y**

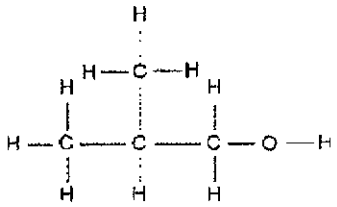
(a) **(iii)** Define *isomer*.

Isomers have the same molecular formulae but different molecular structure [1]

(iv) Name isomer X.

butanol [1]

(b) Draw the full structural formula for isomer Y.



[1]

(c) Isomer X can be manufacture in the lab from an alkene.

(i) State the condition needed to make isomer X.
High temperature, catalyst, high pressure / 600 ºC, phosphoric acid 65 atm [2]

(ii) Name the alkene can be used to make isomer X.
butene / methylpropene / 2 methylprop1ene [1]

(iii) The reaction is exothermic. Draw a labelled energy profile diagram of this reaction, indicating the activation energy and enthalpy change.

[1]- E_a correctly labelled
[1] - ΔH correctly labelled
[1] draw exo energy profile
(reactant higher than product)

[3]

A6 To prepare a pure sample of magnesium nitrate salt, a student carried out reaction using magnesium carbonate powder and dilute nitric acid.

$$MgCO_3 + 2HNO_3 \rightarrow Mg(NO_3)_2 + CO_2 + H_2O$$

The student wants to obtain 20 g of the pure magnesium nitrate crystals, $Mg(NO_3)_2 \cdot 6H_2O$, at the end of the experiment.

(a) The student needs to add excess magnesium carbonate to the dilute nitric acid. Explain how will doing so ensure the purity of the product obtained. [1]

This is to **ensure all the acid has reacted** and not contaminate the salt crystal.

(b) Briefly state the steps required to obtained pure magnesium nitrate crystals after adding excess magnesium carbonate to nitric acid.

Filter out the excess unreacted magnesium carbonate solid
Heat the filtrate to 1/3 its volume to obtain hot saturated solution
Cool the filtrate to allow magnesium nitrate crystals to form gradually
Filter to collect the salt crystals
Wash with a little distilled water
Dry between filter paper

(1c-2c [1], 3c-5c[2], 6c[3]) [3]

(c) The percentage yield for this method of salt preparation is typically around 80%. Assuming the same percentage yield for this experiment, calculate,

(i) the theoretical mass of magnesium nitrate crystal needed to yield 20 g of the crystal,

20 g / 0.8 = **25 g** [1]

theoretical mass of magnesium nitrate crystal: ..... g

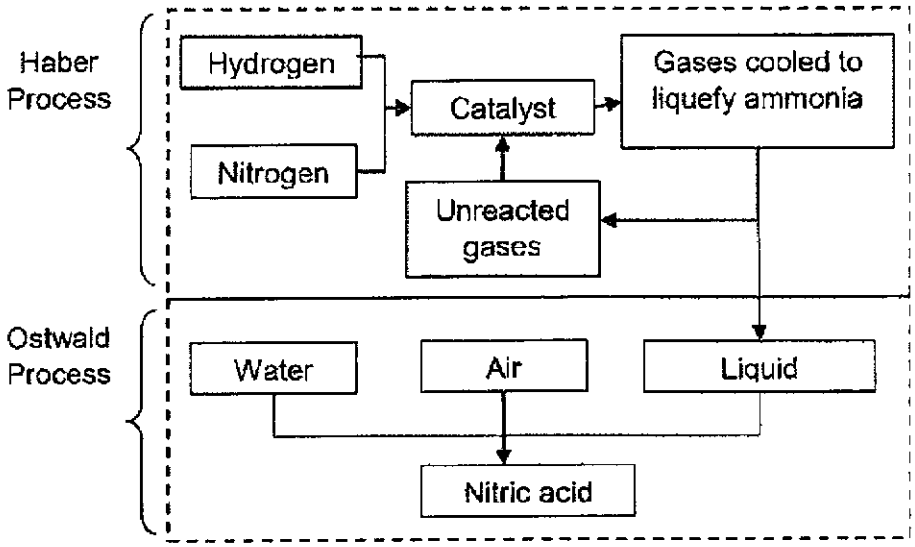
(ii) the volume of 1M nitric acid needed to produce 20 g of pure magnesium nitrate crystal. ($Mg(NO_3)_2 \cdot 6H_2O$, 256)

to produce 20g we need theoretical mass of 25g to 80% yield.
we are to calculate based on theoretical mass 25g

1. convert to mole 25 g of $Mg(NO_3)_2 6H_2O$ to mole: 25/ (24+2{14+3(16)}+6(18))=25/256 = **0.0977 mole [1]**
2. Mole ratio
   $Mg(NO_3)_2$: HNO_3 [4]
   1 : 2 (from eqn)
   0.0977 : (0.0977x2 = **0.1954 mol)[1]**
3. convert to the quantity needed (vol of acid)
   mole/ vol = concentration
   mole/ conc = vol
   0.1954 / 1M = 0.1954 dm^3
   ≈**0.195 dm^3 (3 dp) [1]**

Volume of nitric acid needed= ..... cm^3

A7 The diagram below shows two important industrial processes producing compounds for many other industries to manufacture compounds such as plastics, agricultural materials and explosives.



(a) State the source for each gas used for Haber Process.

hydrogen: **cracking** of long chain hydrocarbon [1]

nitrogen: **fractional distillation of liquefied air**[1] [2]

(b) State the conditions required for Haber process.
250 atm, 400- 450 ºC, iron catatylst [1]

(c) Suggest why air is not used as a raw material in the Haber Process.

oxygen in the air will react with the hydrogen /and nitrogen to form other products / Air **consists of impurities** that will **containinate the catalyst / product**. [1]

(d) When the products of Haber and Ostwald processes reacted together, a new compound is formed.
Suggest one use of the compound.
Fertiliser [1]
accept any other suitable answers: herbicides. and insecticides; and in the manufacture of nitrous oxide, an absorbent for nitrogen oxides, an ingredient of freezing mixtures, explosives, an oxidizer in rocket propellants, and a nutrient for yeast and antibiotics.

B8 (a) With reference to Fig 8.1, complete the table below.

components	process
compressor	Refrigerant vapour gets pressurized and increased in its temperature.
evaporator	The cold mist travel through coils. Air blown over the coils gets cooled. Heat from the air vaporise the refrigerant.
expansion valves	The liquid refrigerant is forced through component. This turns the liquid into a mist and rapid cools it.
condenser	The hot high-pressure vapour moves through coils and lose heat which gets vented outside by fan.

[2]

(b) Describe the change in movement and arrangement of refrigerant particles in the compressor.

pressurized: particles become **closer together [1]**
increase in temperature: particles **moving at higher speed[1]**

[2]

(c) In the upper atmosphere, the ultraviolet trigger chlorofluorocarbon, CFC, to produce chlorine atom and destroy ozone in several steps:

$$CF_2Cl_2 \rightarrow CF_2Cl + Cl$$
$$Cl + O_3 \rightarrow ClO + O_2$$
$$ClO + O_3 \rightarrow 2O_2 + Cl$$

Suggest, with the help of an overall equation, how hydrochlorofluorocarbon, HCFC-22, may pose harm to the ozone layer in the upper atmosphere.

$CHF_2Cl \rightarrow CHF_2 + Cl$
$Cl + O_3 \rightarrow ClO + O_2$
$ClO + O_3 \rightarrow 2O_2 + Cl$

$CHF_2Cl + 2O_3 \rightarrow CHF_2 + 3O_2 + Cl$ [1]

[1]

(d) Powerful greenhouse gas, HFC-23, can be produced from methane.

(i) Draw a dot-and-cross diagram of HFC-23, show all the electron arrangements.

[1] correct pair of electron shared
[1] correction electronic configuration

[2]

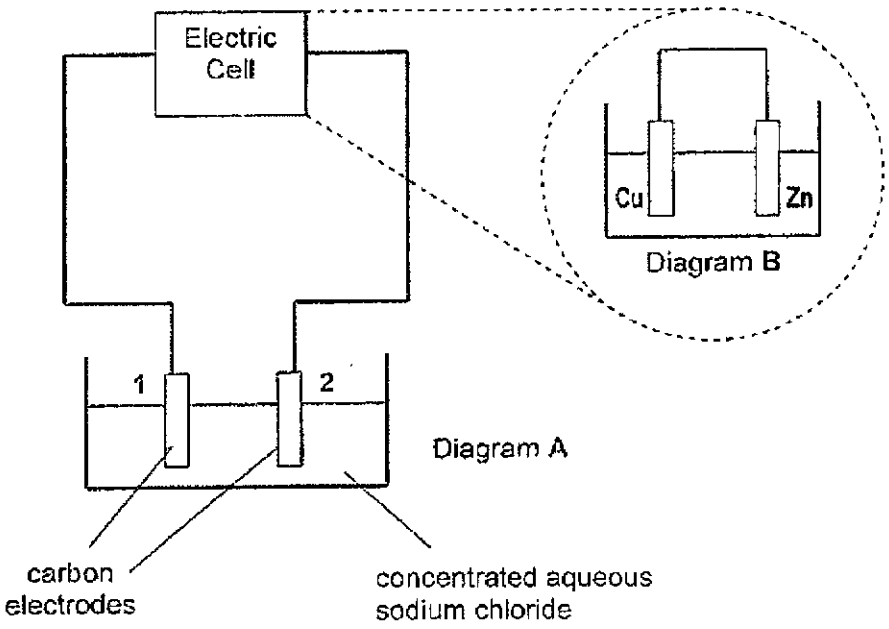
(ii) Describe how HFC-23 may be manufacture from methane. [2]

by substitution [1] of fluorine gas under UV light [1]

(e) During 3rd International Symposium on Engineering and Earth Sciences held last year, a perfect refrigerant is defined to be environment friendly with zero ODP (Ozone Depletion Potential) and low GWP (Global Warming Potential), it should be safe (non-toxic, non-flammable).

Suggest a perfect refrigerant and support with data in Fig 8.2.
carbon dioxide [1]
It has zero ODP, low GWP of 1 and it is non-toxic and non-flammable.
[1] describe
[1] quote data [3]

B9 Diagram A below shows the electrolysis of concentrated aqueous sodium chloride while Diagram B shows the actual electric cell used in the electrolysis. A few drops of Universal Indicator is added to the sodium chloride solution before the start of the experiment.



(a) Write the half-equation for reaction at diagram A:

cathode: $2H^+(aq) + 2e^- \rightarrow H_2(g)$

anode: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$ [2]

(b) State and explain the observations made on the electrolyte in diagram A as the experiment proceeds.

Observation: electrolyte will be turn from green to **blue/indigo/violet solution [1]**
reason: As more hydrogen ions and chloride ions are preferential discharge, more sodium and hydroxide ions are left behind, **electrolyte become more alkaline [1]**. so Universal indicator will turn blue

[2]

(c) **(i)** Draw on Fig 9.1, the direction of electron flow in diagram B. **(from Zn to Cu)**
Accept if student draws on Fig. 9.1, but must be from cathode 1 to 2

(ii) Hence, which electrode in diagram A is anode? [2]

Electrode 1

(d) The electrolyte in diagram A is aqueous copper(II) sulfate solution.

(iii) Describe the observation at copper electrode in diagram B.

increase in mass / size / reddish brown solid deposition

(iv) Suggest how to increase the voltage in diagram A.

change Zn to Mg
Accept any suitable answers: change Cu to silver, have more electric cell

[2]

[Total:8]

EITHER

B10 In the early 19th century, a chemist, Frederich Wöhler, isolated aluminium metal by reacting potassium with aluminium chloride at high temperature.

$$3K + AlCl_3 \rightarrow 3KCl + Al$$

(a) **(i)** Would the enthalpy change for the reaction be positive or negative?
postive[1]

[2]

(ii) Explain your answer in part **(a) (i)**.
Heat is supplied at high temperature suggest the reaction absorb energy [1] from the surrounding, so it is endothermic reaction with positive enthalpy change

(b) Suggest why it was essential that Frederich Wöhler kept water away from his reacting chemicals.

water will react with potassium vigorously producing a lot of heat. [1]

(c) Explain why he used the dangerous and expensive potassium to prepare aluminium rather than the safe and cheaper copper.

copper may be cheap and safe but it not more reactive than aluminium in the metal reactivity series, it is unable to displace / reduce aluminium from its chloride.[1]

Potassium is more reactive than aluminium, it can displace / reduce the less reactive [2] aluminium from its chloride. [1]

Potassium is more reactive than copper1 [1]

(d) A modern scientist recommended performing Frederich Wöhler's experiment in an atmosphere filled with inert argon.

Explain, in terms of electronic structure, why argon can provide an inert environment for the reaction.

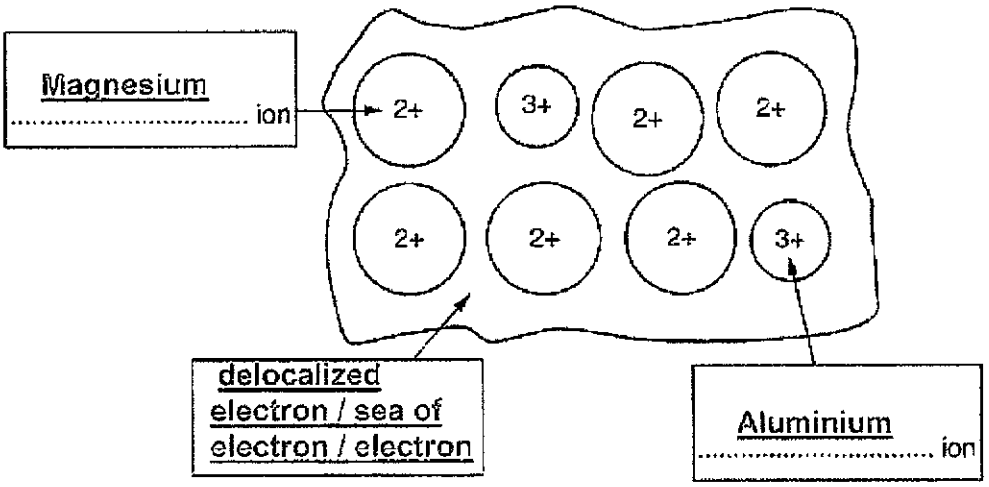
Argon has full outermost shell/ 2.8.8. It is unreactive it will not react with the potassium.

[1]

(need to refer to electronic structure and state it is unreactive)

(f) The aluminium atoms in Magnox form a metallic structure with magnesium. The figure below represents a simple illustration of the bonding in Magnox.

(i) Use your knowledge of atomic structure and metallic bonding to label the boxes.



[2]

(ii) Explain why Magnox is harder than pure magnesium.

There is Aluminium atom of **different size** **disrupt the regular arrangement** of pure magnesium metal atoms, **preventing the layers of magnesium atoms from sliding past each other easily** when force is applied.

1c-3c [1]
4c [2]

OR

B10 The results of an experiment with iron, magnesium and two other metals X and Y and their oxides are summarised in the following tables.

	iron	X	calcium	Y
action of metal on aqueous iron(II) nitrate	no visible reaction	iron is deposited.	iron is deposited and a gas is evolved	no visible reaction

	Fe_2O_3	XO	CaO	Y_2O
action of heat on metal oxide	no visible reaction	no visible reaction	no visible reaction	metal Y is formed

(a) What is the order of reactivity for the four metals, X, Y, iron, and calcium?

most reactive — Calcium

X

Iron

least reactive — Y [1]

(b) Write an ionic equation, with state symbol, for the reaction when X is placed in aqueous iron(II) nitrate.

$X(s) + Fe^{2+}(aq) \rightarrow Fe(s) + X^{2+}(aq)$ corr eqn [1]

(c) When calcium is placed in a beaker of aqueous iron(II) nitrate, iron is deposited and a gas is evolved.

(i) Name this gas.

Hydrogen [1]

(ii) Explain how the gas is formed

Reactive calcium react with the water in the aqueous salt solution to form hydrogen gas [1]

(d) Suggest the identity of metal X and explain your answer.

Zinc. [1]

It is less reactive than calcium, and more reactive than iron.
The charge of the metal ion is 2+.
No gas is evolved when reacted with water, so cannot be magnesium / must be less reactive than magnesium.

3c - 2
1-2c - 1

(e) Metal Y oxide has a formula Y_2O. It has another oxide with the formula of Y_4O_4. Its oxides are coloured. Y is often used as a catalyst in a few reactions.

(i) State the oxidation state of Y in Y_2O.

+1 [1]

(ii) Suggest the identity of Y and explain your answer.

Y can be **silver** [1] because Y does not displace iron(II) nitrate so **lower reactivity** than iron / metal oxide decompose to forms metal on heating suggest it is silver / from the formula Y_2O suggest metal Y has a **+1 charge**

Accept any reasonable explanation that include **low reactivity metal and + 1 charge**