Name: ..... ( ) Class: Sec 4A

Queenstown Secondary School

Preliminary Examination 2021
Secondary Four Express
Chemistry
6092/01

1 September 2021
Wednesday

Time: 1200 – 1300h
Duration: 1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

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

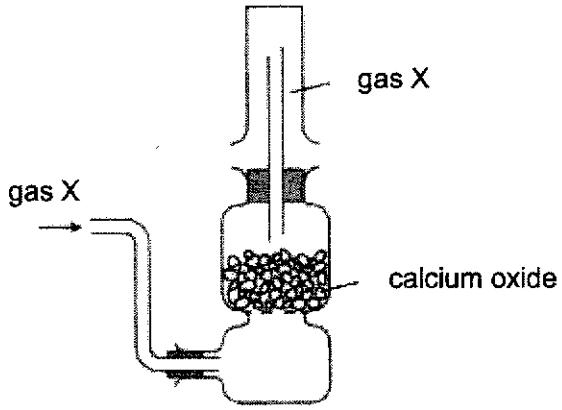
There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet 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 booklet.
A copy of the Periodic Table is printed on page 20.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **20** printed pages.

1 The experimental set-up below is used to collect a clean, dry sample of gas X. Gas X was given off after ammonium chloride and calcium hydroxide was mixed together and heated in a test-tube.

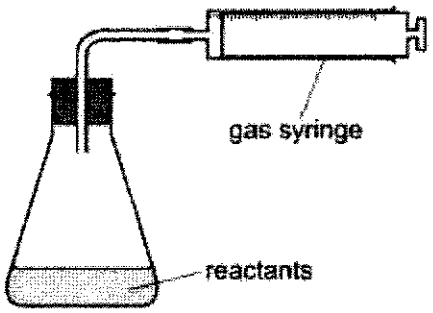


What can be deduced about gas X?

1 It is soluble in water.
2 It is less dense than air.
3 It can also be dried using concentrated sulfuric acid.

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

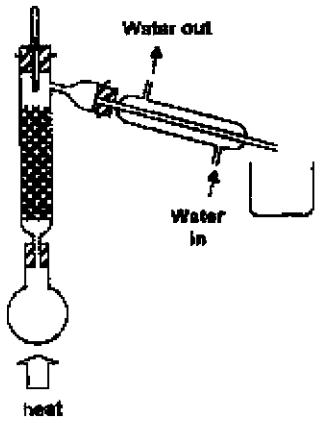
2 The apparatus shown is used to measure the rate of a reaction.



Which of the following reaction rate can be measured using this apparatus?

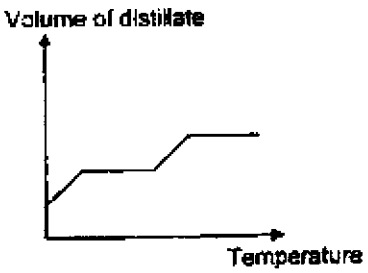
A calcium with dilute hydrochloric acid
B copper with dilute nitric acid
C aqueous sodium carbonate with aqueous silver nitrate
D chlorine with aqueous potassium bromide

3 The diagram shows the apparatus used to separate liquid R (boiling point 70°C) and ethanol (boiling point 98°C).

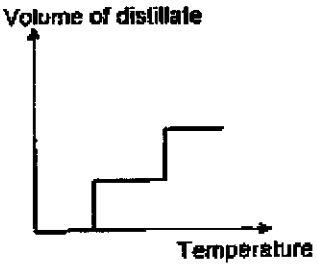


Which graph would be obtained if volume of distillate collected was plotted against temperature?

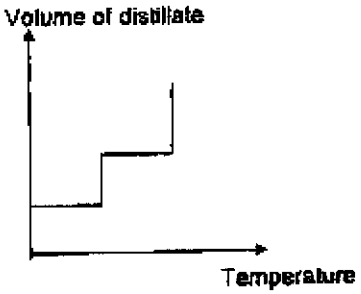
A



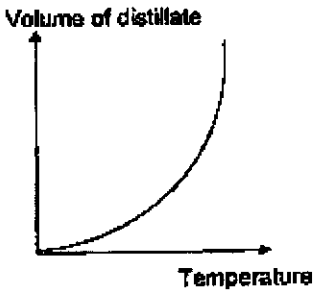
C



B



D



4 Three separations are listed below.

1 Obtaining oil from a mixture of oil and water.

2 Obtaining ammonium chloride from a mixture of ammonium chloride and sodium chloride.

3 Obtaining solid copper(II) sulfate from copper(II) sulfate solution

Which techniques would be involved in separation 1, 2 and 3 respectively?

	1	2	3
A	simple distillation	sublimation	crystallisation
B	simple distillation	crystallisation	filtration
C	separating funnel	sublimation	crystallisation
D	separating funnel	crystallisation	filtration

5 The following observations were recorded after various tests were carried out on a green solid.

- A blue precipitate was observed when aqueous ammonia was added to an aqueous solution of the green solid.
- Effervescence was formed when dilute nitric acid was added to the green solid. Upon adding aqueous barium nitrate to the resultant mixture, no visible reaction was seen.

What could be the identity of the green solid?

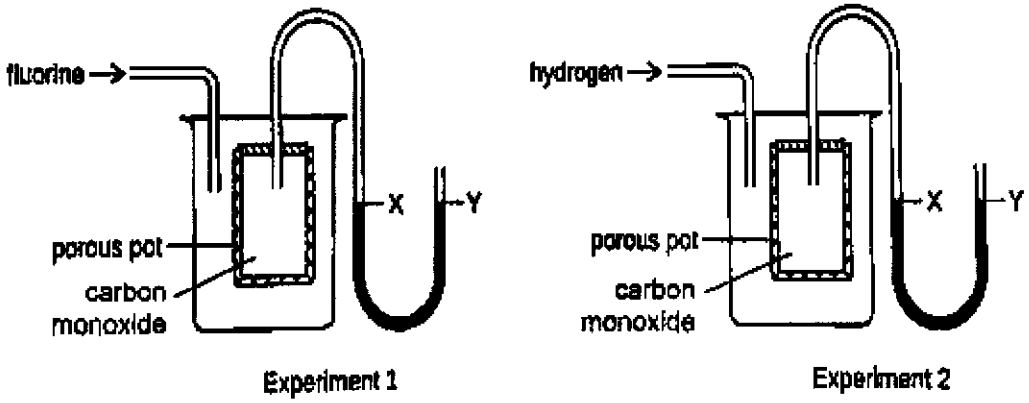
A iron(II) nitrate
B iron(II) sulfate
C copper(II) sulfate
D copper(II) carbonate

6 In an experiment, 4.0cm^3 of 1.0mol/dm^3 iron(III) sulfate solution is mixed with 4.0cm^3 of 1.0mol/dm^3 sodium hydroxide solution.

What does the reaction vessel now contain?

A a green precipitate and an colourless solution
B a green precipitate and an orange solution
C a red-brown precipitate and a colourless solution
D a red-brown precipitate and an orange solution

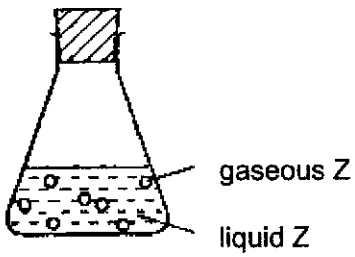
7 Two experimental set-ups used to demonstrate the diffusion of gases are shown in the diagrams below. In each porous pot is carbon monoxide.
In the first experiment, the gas introduced into the beaker is fluorine gas, while in the second experiment, hydrogen gas was introduced.



What changes, if any, to the water levels X and Y would you expect to see in both experiments?

	experiment 1	experiment 2
A	Y is higher than X	X is higher than Y
B	X is higher than Y	Y is higher than X
C	X and Y remain the same	Y is higher than X
D	X and Y remain the same	X and Y remain the same

8 The conical flask contains compound Z which is present in liquid and gaseous states.



Which statement is correct?

A The molecules in gaseous Z slide over each other.

B Energy is lost when compound Z changes from gas to liquid.

C Compound Z sublimed from liquid Z to form gaseous Z.

D Compound Z has a range of boiling points.

9 The table gives some statements about atoms and explanations for these statements. Which row shows both a correct statement and a correct explanation for the statement?

	statement	explanation
A	atoms are electrically neutral	same number of electrons and neutrons
B	atoms of metals tend to gain electrons	to achieve a full valence shell
C	the mass of an atom is concentrated in its nucleus	presence of protons and neutrons in nucleus
D	the nucleus and electrons repel each other	nucleus and electrons have opposite charges

10 The table shows information about particles R and S.

particle	number of		
	protons	neutrons	electrons
R	11	12	10
S	19	20	18

Which of the following statement is correct for both R and S?

A Both are atoms in the same Group.

B Both are isotopes of the same element.

C Both are positive ions in the same Group.

D Both are positive ions in different Groups.

11 Some properties of substances P, Q, R and S are given in the table.

substance	percentage composition by mass	solid conducts electricity	changes on heating
P	varies	no	solid burns to form carbon dioxide and water
Q	constant	yes	solid burns in air to form an oxide
R	varies	no	solid melts
S	constant	yes	solid decomposes

Which classification of substances is correct?

	element	mixture	compound
A	S, Q	P	R
B	Q	P, R	S
C	S	P	Q, R
D	R	P, Q	S

12 Lithium and fluorine react to form lithium fluoride.

A student writes three statements about the reaction.

1 Lithium atoms lose an electron when they react.

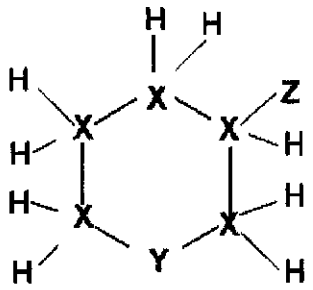
2 Each fluoride ion has one more electron than a fluorine atom.

3 Lithium fluoride consists of strong electrostatic forces between atoms.

Which statements are correct?

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

13 The compound below is made up of hydrogen and the elements X, Y and Z.



Which statement is **incorrect**?

A Element Z is most likely from Group VII.

B Element X is most likely from Group IV.

C The compound is formed by the losing and gaining of electrons.

D The compound has the molecular formula X_5H_9YZ.

14 Carbon and silicon are both in Group IV of the Periodic Table.
At room temperature, CO_2 is a gas whereas SiO_2 is a solid.

Which statement explains this?

A Covalent bonding is weaker in CO_2.

B Covalent bonds in CO_2 are double bonds and in SiO_2 the covalent bonds are single bonds.

C CO_2 is a covalent compound and SiO_2 is an ionic compound.

D CO_2 is a simple covalent molecule and SiO_2 is a giant covalent molecule.

15 Below are four statements about metals.

1 Metals can conduct electricity.
2 Metals have high melting points, except some metals.
3 Metals contain a lattice of positive ions in the presence of delocalised electrons.
4 Metals require a large amount of energy to overcome the strong covalent bonds between the atoms.

Which of the following statements is correct?

A Statement 1 is correct and statement 3 explains statement 1.
B Statement 2 is correct and statement 4 explains statement 2.
C Statement 3 is incorrect and statement 4 is correct.
D All statements are correct but statement 1 does not explain statement 2.

16 Two moles of X decompose rapidly at room temperature to give one mole of oxygen and two moles of bromine.

What is the molecular formula of X?

A BrO_2 **B** Br_2O **C** Br_2O_2 **D** Br_4O_2

17 All ammonium salts produce ammonia gas on heating with sodium hydroxide. Which ammonium salt has the greatest percentage mass of nitrogen?

A NH_4Cl **B** NH_4NO_3 **C** $(NH_4)_2SO_4$ **D** $(NH_4)_3PO_4$

18 12.0 g of anhydrous magnesium sulfate combines with 12.6 g of water to form hydrated magnesium sulfate.

What is the formula of the hydrated magnesium sulfate?

A $MgSO_4.9H_2O$ **B** $MgSO_4.7H_2O$ **C** $MgSO_4.5H_2O$ **D** $MgSO_4.3H_2O$

19 Upon strong heating, a metal nitrate compound undergoes decomposition according to the following equation:

$$2XNO_3\,(s) \rightarrow 2X\,(s) + 2NO_2\,(g) + O_2\,(g)$$

Complete decomposition of 6.80g of the nitrate gives $480cm^3$ of oxygen, measured at room temperature and pressure. What is the relative atomic mass of X?

A 108 **B** 170 **C** 216 **D** 340

20 $0.5mol/dm^3$ sulfuric acid is added gradually to a flask containing $20cm^3$ of $2.0mol/dm^3$ sodium hydroxide solution.

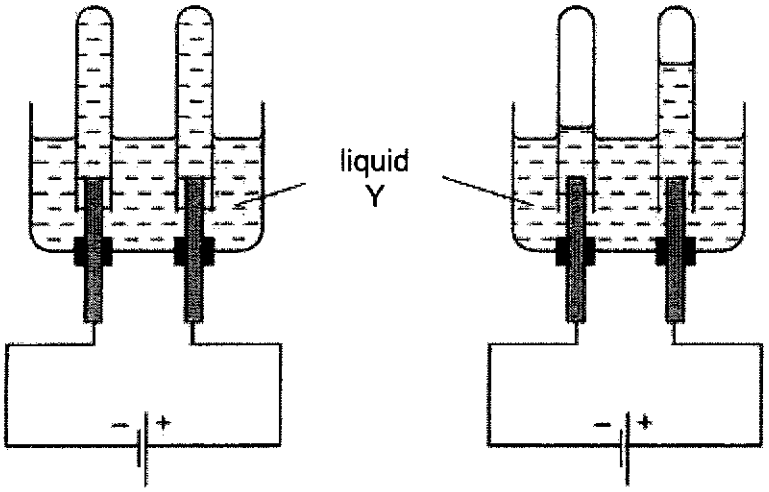
What is the total volume of the mixture in the flask when the solution is just neutral?

A $20cm^3$ **B** $40cm^3$ **C** $60cm^3$ **D** $80cm^3$

21 Magnesium can be produced by electrolysis of molten magnesium chloride, $MgCl_2$. What are the equations for the reactions that occur at the positive electrode and at the negative electrode?

	positive electrode	negative electrode
A	$2Cl^- \rightarrow Cl_2 + 2e^-$	$Mg^{2+} + 2e^- \rightarrow Mg$
B	$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$	$2H^+ + 2e^- \rightarrow H_2$
C	$2Cl^- + 2e^- \rightarrow Cl_2$	$Mg + 2e^- \rightarrow Mg^{2+}$
D	$Mg^{2+} + 2e^- \rightarrow Mg$	$2Cl^- \rightarrow Cl_2 + 2e^-$

22 The diagrams show an electrolysis set-up using inert electrodes.



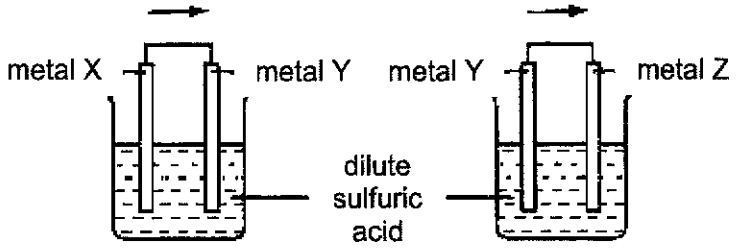
Which could be liquid Y?

1 aqueous magnesium nitrate
2 aqueous copper(II) sulfate
3 concentrated hydrochloric acid
4 dilute sulfuric acid

A 1 and 4 only **B** 2 and 4 only **C** 1, 2 and 4 only **D** 1, 3 and 4 only

23 Two cells were set up as shown in the diagram.

The arrows show the direction of electron flow in the external circuits.



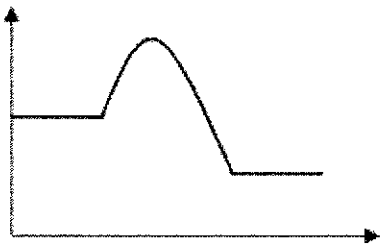
Which set of metals would give the electron flows in the directions shown?

	metal X	metal Y	metal Z
A	Ag	Cu	Zn
B	Ag	Zn	Cu
C	Cu	Zn	Ag
D	Zn	Cu	Ag

24 The reaction between P and Q to produce R is a reversible reaction. The activation energy for the forward reaction is +345 kJ/mol and can be represented as

$$P + Q \rightleftharpoons R \qquad \Delta H = -45 \text{ kJ/mol}$$

The energy profile diagram is shown below.



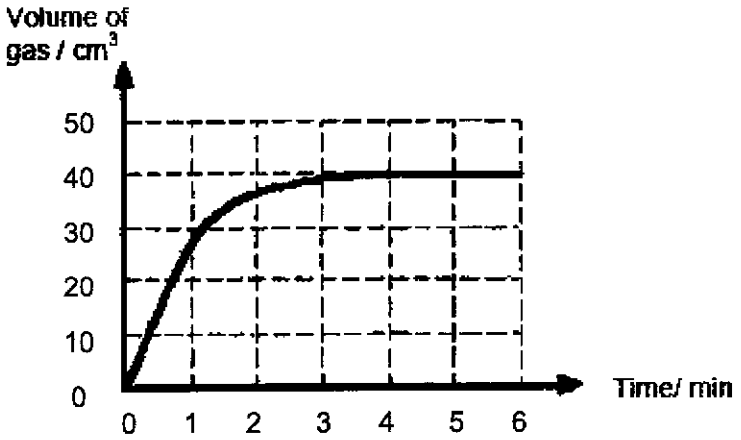
Which of the following options correctly describes the reverse reaction?

	type of reaction	activation energy (in kJ/mol)	ΔH (in kJ/mol)
A	exothermic	+345	-45
B	endothermic	+390	+45
C	exothermic	-345	-45
D	endothermic	-390	+45

25 Which of the following statements best describes the mechanism of a hydrogen-oxygen fuel cell?

A Electricity is used to provide heat energy.
B Electricity is used to generate hydrogen and oxygen.
C Hydrogen ions react with hydroxide ions to generate electricity.
D Hydrogen and oxygen undergo redox reactions to generate electricity.

26 The rate of reaction between pieces of zinc and 1.0mol/dm^3 hydrochloric acid was investigated. The total volume of gas produced every minute was recorded over a period of time. The zinc had completely reacted in the reaction and the results are shown in the graph below.



What would be expected if the experiment was repeated using the same mass of zinc and the same volume of 0.5mol/dm^3 hydrochloric acid?

	maximum volume of gas produced	time at which maximum volume is obtained
A	40cm^3	less than 4 minutes
B	40cm^3	longer than 4 minutes
C	20cm^3	less than 4 minutes
D	20cm^3	longer than 4 minutes

27 A household bleach contains sodium chlorate(I), NaC*l*O, as its active ingredient. When sodium chlorate(I) is stirred into excess aqueous hydrogen peroxide, the reaction that occurs is represented by the following equation.

$$NaClO\,(aq) + H_2O_2\,(aq) \rightarrow NaCl\,(aq) + O_2\,(g) + H_2O\,(l)$$

Which of the following can be deduced from the reaction?

1 Hydrogen peroxide acts as a reducing agent in this reaction.
2 Hydrogen peroxide acts as an oxidising agent in this reaction.
3 The final solution gives a white precipitate with acidified silver nitrate.
4 The final solution bleaches damp litmus paper.

A 1 only **B** 2 only **C** 1 and 3 **D** 2 and 4

28 Which of the following statements about sulfuric acid is/are true?

1 It is used to make fertilisers.
2 It causes Universal Indicator to turn orange due to the low amount of H^+ ions.
3 It reacts with sodium hydroxide to form a soluble salt and hydrogen gas.
4 It reacts with lead(II) carbonate to form an insoluble salt, carbon dioxide and water.

A 1 and 2 only **B** 1 and 4 only **C** 2 and 3 only **D** 3 and 4 only

29 Which of the following salts can be prepared using the same method?

A zinc chloride, calcium sulfate
B potassium iodide, lead(II) iodide
C copper(II) sulfate, lead(II) nitrate
D potassium nitrate, magnesium nitrate

30 Which of the following are true of Haber Process?

1 Nitrogen is obtained from the cracking of petroleum.
2 1 mole of nitrogen reacts with 3 moles of hydrogen to form ammonia.
3 Unreacted nitrogen and hydrogen are released into the atmosphere.
4 Finely divided iron provides an alternative pathway with lower activation energy.

A 1 and 2 only **B** 1 and 3 only **C** 2 and 4 only **D** 3 and 4 only

31 The table below shows some information of three elements.

element	P	Q	R
atomic number	10	11	7

Which of the following statements about the elements is correct?

A P exists as a monatomic element and is used to fill up balloons.
B P and R are in the same period as their atoms occupy two electron shells each.
C The compound formed between P and Q has a high melting point.
D Q and R form a compound that has a formula of QR_3.

32 Rubidium, Rb, is an element in the same group of the Periodic Table as lithium, sodium and potassium.

Which statement about rubidium is likely to be correct?

A It forms a manganate with the formula $RbMnO_4$.
B It forms an insoluble hydroxide.
C It is obtained by the electrolysis of aqueous rubidium chloride.
D It reacts slowly with cold water to form an alkaline solution.

33 The information below shows the percentage of carbon in two samples of steel, Q and R. Q consists of 60% carbon while R consists of 20% carbon.

Which statement is correct about the two samples of steel?

A Q has higher strength and less brittle than R.

B R has higher strength and more brittle than Q.

C Q has lower strength and more brittle than R.

D R has lower strength and less brittle than Q.

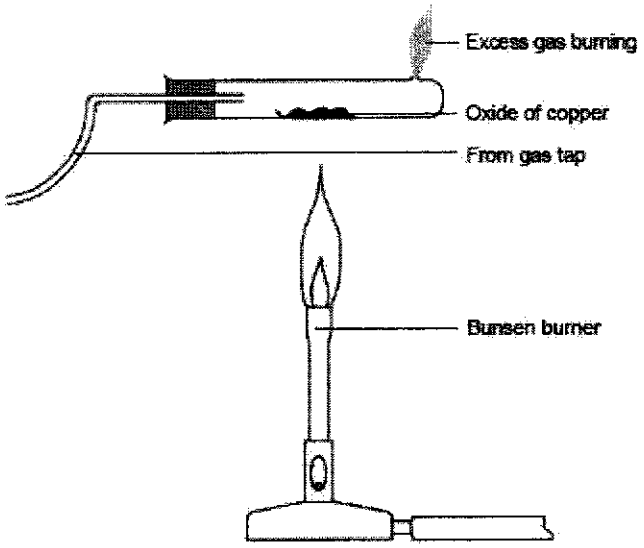
34 The table below provides information on the chemical properties of four metals and some of their compounds.

metal	metal + steam	metal oxide + coke	strong heating of metal carbonate
W	H_2 evolved	oxide reduced	CO_2 evolved
X	H_2 evolved	no visible reaction	no visible reaction
Y	no visible reaction	oxide reduced	CO_2 evolved
Z	H_2 evolved	no visible reaction	CO_2 evolved

Which of the following shows the correct order of reactivity of the metals?

	most reactive		→	least reactive
A	Y	W	Z	X
B	X	Z	W	Y
C	Z	X	W	Y
D	W	X	Y	Z

35 The following set-up is used to study the reduction of an oxide of copper.
The oxide of copper is Cu_2O, which is a red solid.
What would be observed when the reaction has stopped, and what is the purpose of burning the excess gas?

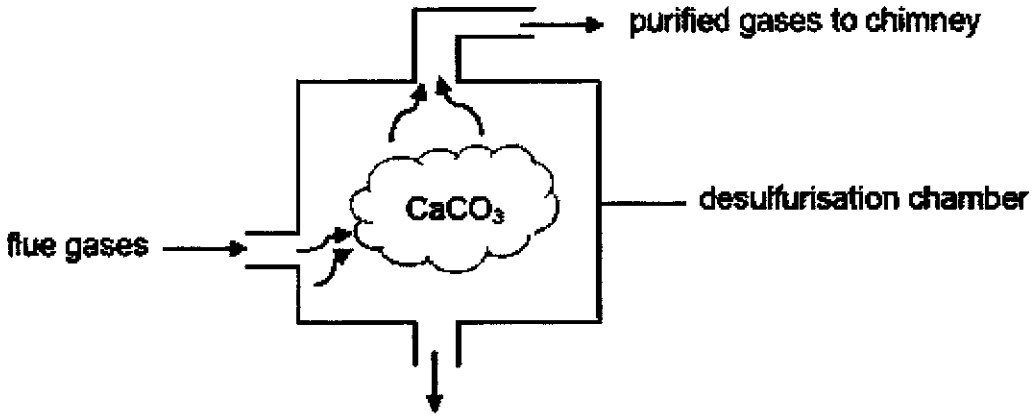


	observation	purpose for burning excess gas
A	red solid turns brown	hydrogen gas used to reduce oxide is highly flammable
B	red solid remains unchanged	carbon monoxide used to reduce oxide is poisonous
C	red solid turns brown	carbon dioxide is a pollutant
D	red solid turns black	nitrogen dioxide gas used to reduce oxide is a pollutant

36 Which of following reactions does **not** occur in a blast furnace during the extraction of iron?

A $CaO + CO_2 \rightarrow CaCO_3$
B $CaO + SiO_2 \rightarrow CaSiO_3$
C $CO_2 + C \rightarrow 2CO$
D $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

37 The following diagram shows a simplified process of desulfurisation.



Which of the following correctly describes the process?

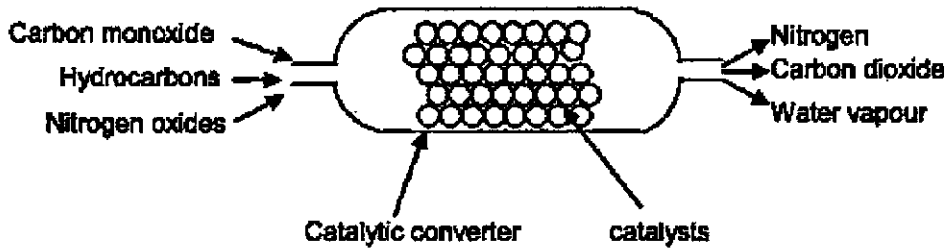
A The purified gases give a white precipitate in limewater.

B Carbon monoxide present in the flue gases reacts with $CaCO_3$.

C The purified gases decolourise acidified aqueous potassium manganate(VII).

D The desulfurisation process is a redox reaction.

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



Which process(es) take(s) place in the converter?

1 Hydrocarbons are reduced to form carbon dioxide and water vapour.

2 Carbon monoxide reacts with nitrogen oxides to form carbon dioxide and nitrogen.

3 Nitrogen oxides react with hydrocarbons to form water vapour and nitrogen.

4 Redox reactions occur.

A 1 and 2 only **B** 2 and 3 only **C** 2 and 4 only **D** 3 and 4 only

39 The average temperature of the Earth has been observed to be increasing gradually.

1 Depletion of ozone layer
2 Increase in rate of growth of plants and animals
3 Increase in droughts, wildfires and heavier rainfall
4 Increase in melting of glaciers and ice caps, leading to increase in sea levels

Which of the above describe the environmental effects of an increase in Earth's temperature?

A 1 and 2 only **B** 1, 2 and 3 **C** 3 and 4 only **D** 2, 3 and 4

40 Biodiesel, an alternative fuel made from vegetable oil, can be used as a fuel for vehicles. Although carbon dioxide is released during the combustion of biodiesel, scientists still claim that it is a carbon neutral fuel.

Which is the basis for this claim?

A Biodiesel is not a carbon compound.
B Biodiesel produces less carbon dioxide when it burns.
C Plants release carbon dioxide during respiration.
D Plants absorb carbon dioxide during photosynthesis.

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 -		

Key

proton (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.)

Name: ..... ( ) Class: Sec 4A

Queenstown Secondary School

Preliminary Examination 2021
Secondary Four Express
Chemistry
6092/02

25 August 2021
Wednesday

Time: 1100 – 1245h
Duration: 1 hour 45 minutes

Additional Materials: Candidates answer on the Question Paper.
No Additional Materials are required.

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 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 21.

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

Examiner's Use	
Section A	/50
Section B	/30
B8	
B9	
B10	
TOTAL	/80

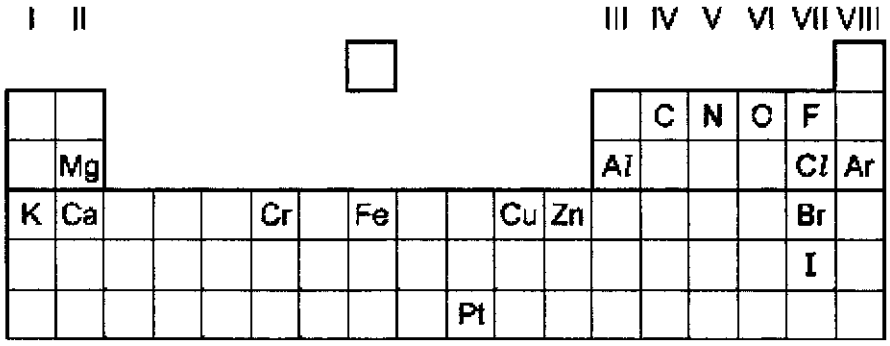
This document consists of **21** printed pages.

Section A

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

The total mark for this section is 50.

A1 The diagram shows part of the Periodic Table.



Answer the following questions using only the symbols of the elements in the diagram.

Each symbol may be used once, more than once or not at all.

Give the symbol of the element that:

(a) forms a compound which is used to remove acidic impurities in iron extraction, ... [1]

(b) consists of strong covalent bonds between its atoms arranged in a tetrahedral manner, ... [1]

(c) forms an aqueous solution that undergoes complete ionisation to produce a high concentration of hydroxide ions, ... [1]

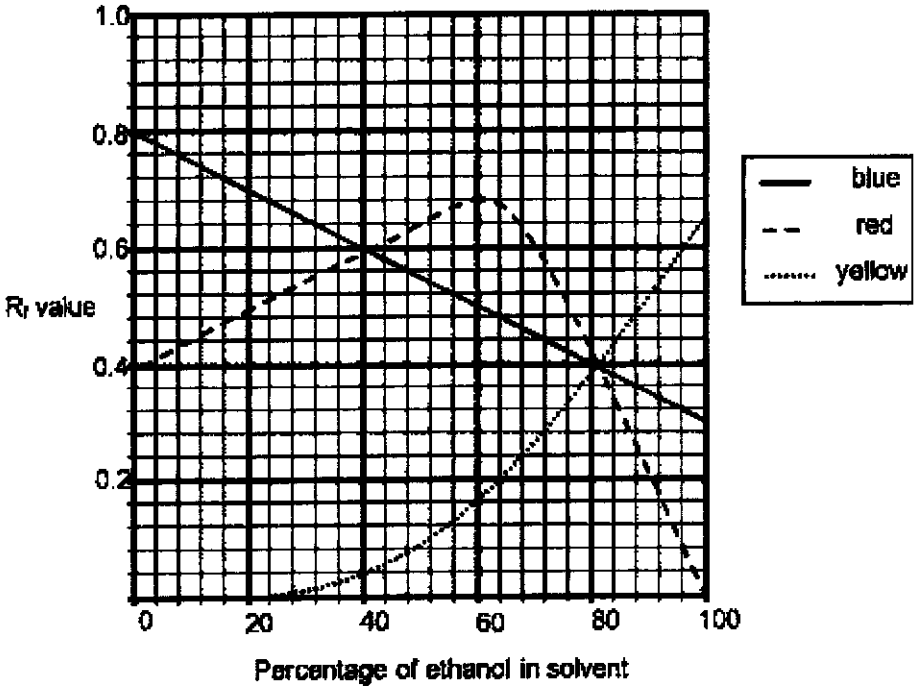
(d) forms an oxide that reacts with both dilute nitric acid and aqueous sodium hydroxide, ... [1]

(e) is used to fill light bulbs, ... [1]

(f) has variable oxidation states. ..... [1]

[Total: 6]

A2 Black ink contains a mixture of red, blue and yellow dyes. To separate the dyes, the solvent used is a mixture of ethanol and water. Each of the coloured dyes have different R_f values in solvents with different percentages of ethanol in the solvent mixture.



(a) Deduce the R_f value of the yellow dye on the chromatogram when the solvent consists of $40cm^3$ of ethanol and $160cm^3$ of water.

R_f value ..... [1]

(b) Using the information from the graph, justify if the black ink can be separated by using only water as the solvent for paper chromatography.

.....

.....

..... [2]

(c) Wayne carried out paper chromatography on the black ink using a mixture of ethanol and water as the solvent. He discovered only one spot forming on the resulting chromatogram.

Using evidence from the graph, explain why he cannot conclude that the black ink is a pure substance.

.....

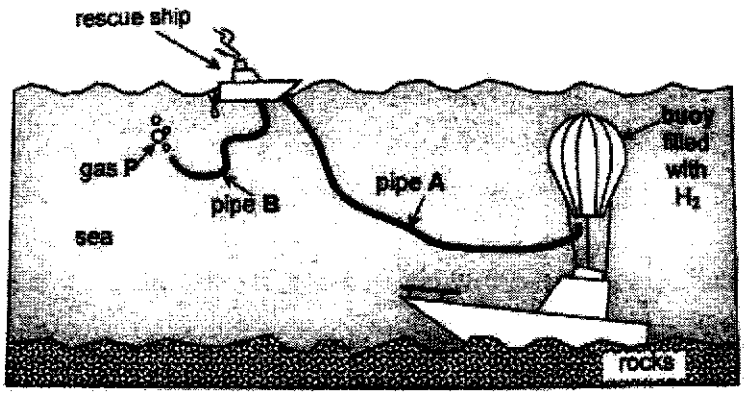
.....

.....

..... [2]

[Total: 5]

A3 A ship sank after a collision with an iceberg in the sea. Scientists proposed to lift the ship by attaching inflatable buoys to it. The buoys are to be filled with hydrogen gas, which is formed by the electrolysis of seawater, which consists mainly of concentrated aqueous sodium chloride, as shown in the diagram below.



(a) **(i)** Is pipe **A** connected to the cathode or anode? Explain your answer.

..... [1]

(ii) Write the ionic equation for the reaction that produces hydrogen gas at pipe **A**.

..... [1]

(iii) Identify gas **P**.

..... [1]

(b) A sample of the seawater was taken to the laboratory. Electrolysis of the seawater was carried out using carbon electrodes.

Describe and explain how the pH of the electrolyte changes.

.....

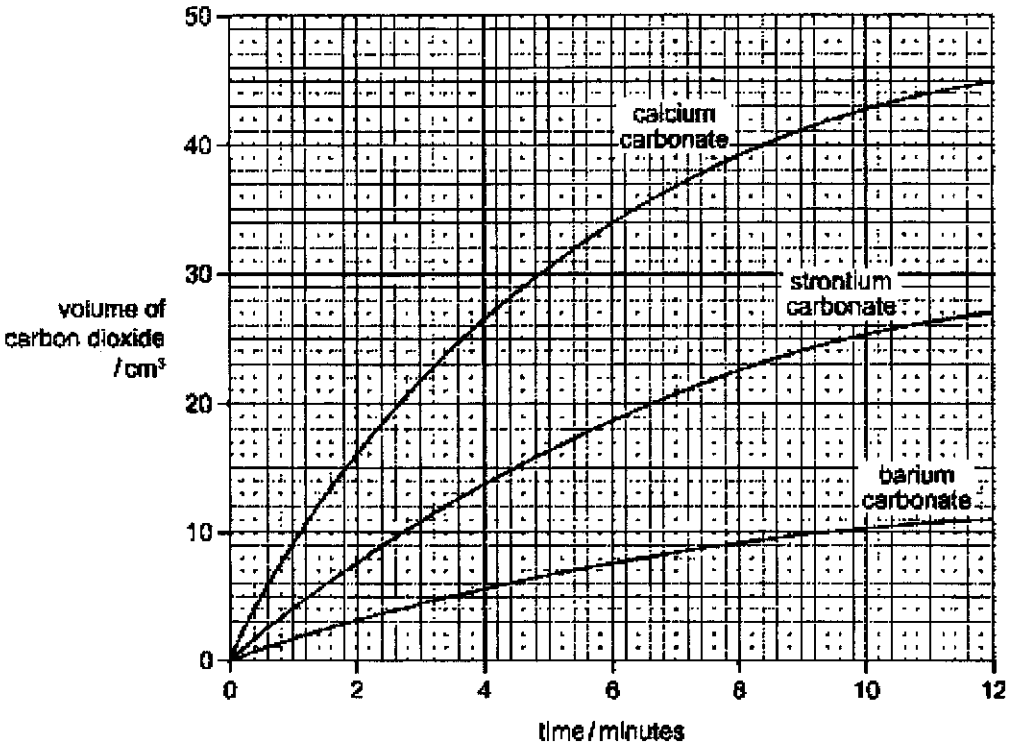
.....

.....

..... [2]

[Total: 5]

A4 The graph shows the volume of carbon dioxide released when the three granular metal carbonates were heated.



(a) Which carbonate produced carbon dioxide at the highest rate?

..... [1]

(b) How do the rates of the reactions of the three metal carbonates relate to the positions of calcium, strontium and barium in the Periodic Table?

.....

.....

.....

.....

.....

..... [2]

(c) Strontium carbonate is used in electronic applications.

(i) Describe a test to confirm the presence of carbonate ions.

test .....

result..... [2]

(ii) Deduce the number of electrons, protons and neutrons in one strontium ion.

number of electrons .....

number of protons .....

number of neutrons ..... [2]

(iii) Describe how strontium carbonate can be prepared in the laboratory.

.....

.....

.....

.....

.....

..... [3]

(d) Describe the effect each of the following has on the rate of reaction, assuming all other conditions remain the same.

(i) The temperature is increased.

.....

..... [1]

(ii) Powdered carbonate is used.

.....

..... [1]

[Total: 12]

A5 The table shows some properties of three halogens

element	melting point /°C	boiling point /°C
fluorine	-220	-188
bromine	-7	59
iodine	114	184

(a) Besides the increase in melting and boiling points down the group, state another trend for the Group VII elements.

..... [1]

(b) **(i)** Deduce the physical state of bromine at 10°C.

..... [1]

(ii) Compare the differences in the arrangement and movement of fluorine molecules below its melting point and above its boiling point.

.....

.....

.....

..... [2]

(c) **(i)** Bromine reacts with 11.5g of sodium to form 30.9g of sodium bromide. Calculate the percentage yield of sodium bromide.

percentage yield = ...% [2]

(ii) Fluorine was then added to the product sodium bromide.

Describe what would be observed from the reaction and explain your answer.

.....

.....

.....

..... [2]

(iii) Sodium bromide has a melting point of 747°C, which is much higher than bromine's melting point. This is because ionic bonds are much stronger than covalent bonds.

Do you agree with this statement? Explain your answer.

.....

.....

.....

..... [2]

[Total: 10]

A6 Nitrogen and hydrogen react to form ammonia in the Haber process.

The table below shows some bond energies.

bond	bond energy in kJ/mol
N = N	456
N ≡ N	945
N – H	391
H – H	436

(a) Using the information given in the table, calculate the enthalpy change when hydrogen and nitrogen react to form ammonia and hence, deduce if the reaction is an exothermic or endothermic reaction.

[3]

(b) Iron catalyses the reaction.

Explain how iron affects the rate of reaction in the Haber process.

.....

.....

..... [2]

(c) Other than iron catalyst, state the conditions used in the Haber process.

..... [1]

(d) The nitrogen and hydrogen are mixed in a 1 : 3 ratio by volume.

Explain why the gases are mixed in a 1 : 3 ratio. Include an equation in your answer.

.....

.....

..... [2]

[Total: 8]

A7 Alloys are usually used in our daily lives – kitchenware, infrastructures, automobile parts and so on. They are even used to electroplate metals. They improve the mechanical properties of metals.

(a) Explain how alloys can improve the mechanical properties of metals.

.....

.....

..... [2]

(b) Iron is a metal that rusts easily to form iron(III) oxide.

A block of magnesium can be placed near the iron metal to prevent iron from rusting.

Explain how this prevents iron from rusting.

.....

.....

..... [2]

[Total: 4]

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 The information below shows some issues in the automobile industry.

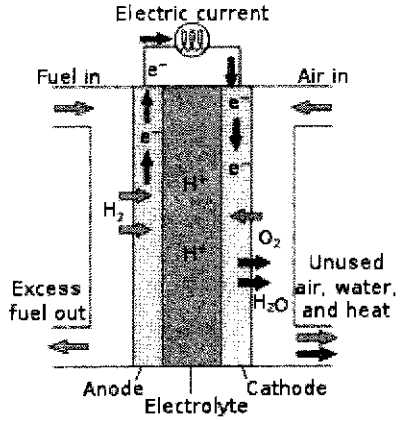
As part of the Singapore Green Plan, the government will require all new car and taxi registration to be of cleaner-energy models from 2030 onwards. Currently, most of the internal combustion engine (ICE) vehicles in Singapore run on petrol or diesel, and this contributes to 6.4 million tonnes of CO_2-equivalent per year. However, if EV was used, the amount of CO_2 production would decrease to about 2 million tonnes per year.
Source: https://www.channelnewsasia.com/singapore/diesel-cars-taxis-new-registration-to-end-2025-ong-ye-kung-257916

Comparison between ICE and EV
ICE vehicles are less fuel efficient, with 16-25% of energy from the fuel being converted to move the vehicle. The rest of the energy is either lost as heat, friction and etc. Octane, C_8H_{18}, is the fuel used to power ICE vehicles.

EV are more efficient, with 59-62% of the electrical energy used to power the energy, without the production of harmful pollutants. However, the life-cycle emissions of EVs, during the manufacture phase, harmful gases are produced from the mining of lithium which is used in the batteries to power the cars. Also, the electricity generated to power the EV also contributes to the high level of air pollutants.
Source: https://carro.sg/blog/internal-combustion-engine-vehicle-vs-electric/

Types of EVs
There are two types of EVs in the market now. One of them is the hydrogen fuel cell electric vehicles (FCEVs), and the other is the more common battery electric vehicle (BEVs).

FCEVs
A hydrogen fuel cell is an electrochemical device that works like a battery, which converts chemical energy from the fuel to electrical energy in a chemical reaction between hydrogen and oxygen.
The hydrogen fuel cell consists of two electrodes containing platinum catalyst, between which is an electrolyte. The catalyst enables the hydrogen molecules to be separated into electrons and ions. The polymer electrolyte membrane (PEM) allows positive ions to migrate through it, while blocking electrons. Oxygen in the air reacts at one electrode and the hydrogen fuel, on the other. The only product is water.
Figure 8.1 below shows how a hydrogen fuel cell work.



Source: https://en.wikipedia.org/wiki/Proton-exchange_membrane_fuel_cell

Figure 8.1

The table below shows some information about hydrogen and octane.

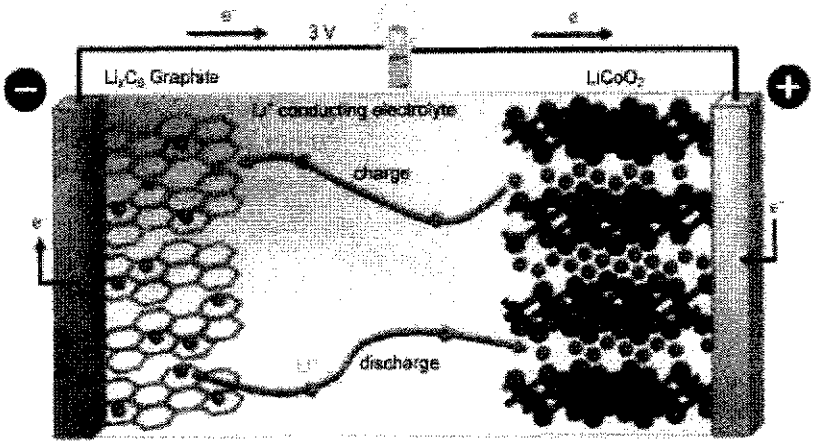
fuel	boiling point / °C	density at room temperature and pressure g/dm^3	volume of 1 mol of fuel at room temperature and pressure /dm^3	enthalpy change when 1 mol of fuel is completely burned in kJ/mol	enthalpy change when 1 kg of fuel is completely burned in kJ/kg
hydrogen	-253	0.083	24		-143 000
octane C_8H_{18}	125		0.162	-5075	

Table 8.2

BEVs

Lithium-ion batteries are most commonly used to power BEVs. It contains a graphite anode, a lithium metal oxide cathode and an electrolyte which is a mixture of a lithium salt and an organic solvent. When electricity is applied on the cell, the battery goes in a "charge" mode, where the lithium ions and electrons are separated from the lithium metal oxide cathode. The electrons will move towards the graphite anode through the wire, while the lithium ions move across the electrolyte and will be stored at the graphite anode. The cell is fully charged when all lithium ions and electrons are stored at the graphite anode.

When a battery is connected to power a load, e.g. lightbulb, the "discharge" phase occurs. Electrons and lithium ions will move back to the lithium metal oxide cathode. This creates an electrical current through the load. Figure 8.3 shows the electron flow when a load is applied.



Source: https://www.technology.matthey.com/article/59/1/4-13/

Figure 8.3

(a) Complete Table 8.2 on hydrogen and octane.

Use the space below to show your working.

[3]

(b) Using information from Table 8.2, evaluate the use of hydrogen and octane as fuels. Your answer should consider the ease of storage or the energy content of the fuels.

.....

.....

..... [1]

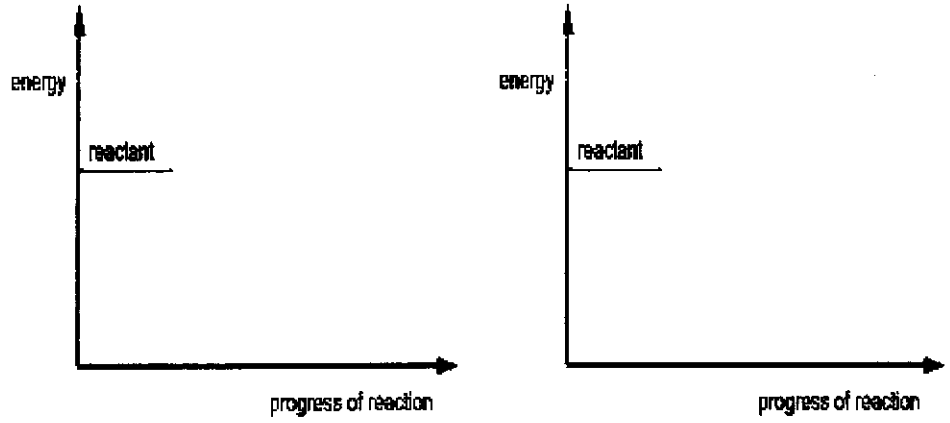
(c) Write the half equations for the cathode and anode for the hydrogen fuel cell.

cathode .....

anode..... [2]

(d) The energy output of a fuel cell can be shown using an energy profile diagram.

Complete and label the energy profile diagrams to show the effect of the catalyst on the energy changes in the hydrogen fuel cell.



reaction without catalyst **reaction with catalyst** [3]

(e) Lithium-ion battery is different from the conventional simple cell.

Compare and contrast the two types of cells.

.....

.....

.....

..... [2]

(f) "Oxidation occurs at the anode when the lithium-ion battery is charged."

Comment on the validity of the statement.

.....

..... [1]

[Total: 12]

B9 People who suffer from kidney disease are encouraged not to consume starfruit because the fruit contains high levels of oxalic acid, which is dibasic.
The formula of oxalic acid can be represented by H_2A.

The concentration of oxalic acid is approximately between 0.5mol/dm^3 to 1.0mol/dm^3. The concentration of the acid can be determined through performing an acid-base titration with aqueous sodium hydroxide.

Teluo suggested that 25.0cm^3 of oxalic acid from the starfruit should be pipetted into a conical flask and titrated against 1.6mol/dm^3 of aqueous sodium hydroxide using a burette.

He rinsed the pipette and conical flask with tap water, distilled water, followed by oxalic acid. He then rinsed the burette with tap water, distilled water, followed by aqueous sodium hydroxide.

(a) State the error made and explain how this error affects the results.

.....

..... [1]

(b) Assuming that the error was corrected, based on the information provided, calculate the maximum volume of aqueous sodium hydroxide needed for complete neutralisation.

[2]

(c) Oxalic acid contains 2.20% of hydrogen and 26.7% of carbon by mass. The rest is oxygen.

(i) Determine the empirical formula of oxalic acid.

[2]

(ii) Given that the relative molecular mass is 90, determine the molecular formula of oxalic acid.

[1]

(iii) A patient was advised not to consume more than 0.05g of oxalic acid per day. If a serving of starfruit contains 0.00013227mol of oxalic acid, calculate the maximum number of servings of starfruit the patient can consume daily.

[2]

[Total: 8]

B10 EITHER

Titanium is a rare and expensive metal, and it is higher than carbon in the reactivity series. It is extracted from rutile, which is a mineral composed mainly of titanium dioxide, TiO_2. Figure 10.1 shows the extraction of titanium.

step 1	Titanium dioxide reacts with chlorine and coke at 1000°C to produce titanium tetrachloride, $TiCl_4$ and carbon monoxide. Titanium tetrachloride is cooled and collected. $TiCl_4$ exists as a colourless liquid at room temperature and pressure, and its boiling point is 136°C.
step 2	Titanium tetrachloride is then reacted with magnesium at a temperature of 1100°C in a sealed reactor for 3 days to obtain titanium.
step 3	The reactor is cooled and opened to obtain titanium and the other product is magnesium chloride.

Figure 10.1

(a) **(i)** Based on the above information, deduce the structure and bonding present in titanium tetrachloride, $TiCl_4$. Explain your answer.

.....

.....

..... [2]

(ii) What is unusual about the bonding present in titanium tetrachloride, $TiCl_4$? Explain your answer.

.....

..... [1]

(iii) Hence, suggest a reason why the electrolysis of titanium tetrachloride, $TiCl_4$, is **not** used as a method to extract titanium.

.....

.....

.....

..... [2]

(b) **(i)** Write the chemical equation to show the reaction that occurred in **step 1**.

..... [1]

(ii) Explain how the product(s) from **step 1** affect the health of humans.

.....

..... [1]

(c) **(i)** Write the chemical equation to show the reaction that occurred in **step 2**.

..... [1]

(ii) What can you deduce from the reaction in **step 2** regarding the reactivity of magnesium and titanium? Explain your answer.

.....

.....

.....

..... [2]

[Total: 10]

B10 OR

Interhalogen compounds are formed between atoms of different Group VII elements and these are very strong oxidising agents.

(a) Fluorine and chlorine react exothermically to form chlorine trifluoride, ClF_3. This product is poisonous and extremely reactive and is used as part of nuclear fuel processing and reprocessing, by the fluorination of uranium metal.

(i) Draw the 'dot-and-cross' diagram to show the outer electrons in the bonding of chlorine trifluoride.

[2]

(ii) When chlorine trifluoride, ClF_3, is added to water, it reacts vigorously to produce three gases. One of the gases produced is hydrogen fluoride. Another gas turns damp blue litmus red and then bleaches it. The third gas relights a glowing splint.

Write the chemical equation for the reaction between chlorine trifluoride and water.

..... [2]

(b) Chlorine trifluoride, ClF_3, reacts with uranium to produce uranium hexafluoride, UF_6, in the following equation.

$$U + 3ClF_3 \rightarrow UF_6 + 3ClF$$

(i) Complete the table to show the oxidation states of uranium and fluorine.

element	oxidation state in reactants	oxidation state in products
uranium		+6
chlorine	+3	+1
fluorine	-1	

[1]

(ii) Using your answers in **(b)(i)**, explain why this is a redox reaction.

.....

.....

.....

..... [2]

(c) Another interhalogen compound is BrF_3. The liquid of this compound is able to conduct electricity.

Complete the following equation and use it to explain why BrF_3 can conduct electricity while bromine and fluorine are non-conductors of electricity.

$$BrF_3 \rightarrow BrF_2^+ + ...$$

.....

.....

.....

.....

..... [3]

[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

proton (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.)

MARK SCHEME

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

MARK SCHEME

Section A [50 m]

A1	(a) Ca (b) C (c) K (d) Zn / Al (e) Ar (f) Fe / Cu / Cr / Pt	[3] [3]
A2	(a) 0 (20% ethanol) (b) Yes. From the graph, the R_f values of the blue ink and the red ink are different (i.e. the blue ink will travels further up the chromatogram than the red ink), while the R_f value of the yellow ink is 0 (i.e. the yellow ink remains insoluble at the original spot). Hence, all the three components of black ink can be separated. (c) From the graph, he must have used 80% ethanol, where all the 3 dyes had the same R_f value of 0.4. (i.e. had the same solubility / travelled the same distance), hence appeared only as one spot.	[1] [1] [1] [1] [1]
A3	(a) (i) Cathode, as the hydrogen ion is discharged to form hydrogen gas. (ii) $2H^+(aq) + 2e^- \rightarrow H_2(g)$ (iii) Chlorine / Cl_2 (b) The pH of the electrolyte increases. During the electrolysis, the H^+ and Cl^- ions are discharged, leaving behind Na^+ and OH^- ions, forming sodium hydroxide, which is an alkaline solution.	[1] [1] [1] [1] [1]
A4	(a) calcium carbonate (b) The faster the rate of decomposition, the less stable the metal carbonate, the less reactive the metal is, the higher the position of the metal in Group II. From the graph, the rate of decomposition of calcium carbonate is the fastest while that of barium carbonate is the slowest. This shows that calcium carbonate is the least stable while barium carbonate is the most stable. Hence, calcium is the least reactive metal while barium is the most reactive metal in Group II. (c) (i) test: add dilute hydrochloric / nitric acid result: effervescence is observed, gas evolved gives white precipitate with limewater (ii) 36 electrons; 38 protons; 50 neutrons (iii) 1. Mix aqueous solutions of strontium nitrate and sodium carbonate together. 2. Filter the mixture to obtain strontium carbonate as residue. 3. Wash the residue with distilled water. 4. Dry the residue by pressing between two pieces of filter paper. (d) (i) An increase in temperature increases the rate of reaction, as the reactant particles gain kinetic energy and move faster, leading to more effective collisions between the particles. (ii) The use of powdered carbonate increases the rate of reaction, as there is an increase in available surface area of contact between	[1] [1] [1] [1] [1] [2] [1] [1] [1] [1] [1]

	reactant particles, leading to more effective collisions between the particles.	
A5	(a) The colour intensity increases / reactivity decreases down Group VII.	[1]
	(b) (i) liquid	[1]
	(ii) arrangement: Fluorine molecules are packed very closely together in an orderly manner below its melting point, while fluorine molecules are far apart in a random arrangement above its boiling point.	[1]
	movement: Fluorine molecules vibrate about a fixed position below its melting point, while fluorine molecules are free to move above its boiling point.	[1]
	(c) (i) $2Na + Br_2 \rightarrow 2NaBr$ Fr. Eqn.: 2 2 Given : 11.5g ?g A_r / M_r : 23 103 0.5mol 0.5mol theoretical mass of NaBr = 0.5 x 103 = 51.5g % yield = 30.9/51.5 x 100 = 60%	[1]
	(ii) The colourless solution turns red-brown.	[1]
	Fluorine, being more reactive than bromine, displaces bromine from sodium bromide.	[1]
		[1]
	(iii) No. **[covalent bonds (strong) ≠ intermolecular forces (weak)]** Sodium bromide has a higher melting point, as a larger amount of heat energy is required to overcome the strong electrostatic forces of attraction between the oppositely charged **ions**.	[1]
	Bromine has a lower melting point, as a smaller amount of heat energy is required to overcome the weak intermolecular forces of attraction between the **molecules**.	[1]
A6	(a) energy absorbed for bond breaking = 945 + 3(436) = 2253 kJ	[1]
	energy released in bond forming = 6(391) = 2346 kJ	[1]
	enthalpy change = 2253 + (-2346) = -93kJ	[1]
	Hence, the reaction is exothermic.	
	(b) Iron, being a catalyst, provides an alternative pathway with a lower activation energy, allowing more reactant particles to possess the minimum energy to react, leading to more effective collisions between the particles, resulting in a faster rate of reaction increases.	[1]
		[1]
	(c) 400-450°C and 200atm	[1]
	(d) $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$	[1]
	From the equation, 1 mole of nitrogen reacts with 3 moles of hydrogen to produce 2 moles of ammonia.	[1]
A7	(a) Alloys can improve the mechanical properties of metals by increasing the hardness and strength of the pure metals.	[1]
	In alloys, the presence of atoms of a different size disrupts the orderly arrangement of atoms, causing the layers of atoms to be unable to slide over each other easily.	[1]
	(b) Magnesium prevents iron from rusting using the sacrificial protection method. Magnesium, being more reactive than iron, corrodes in place of iron.	[1] [1]

Section B [30 m]

B8	**(a)**	1mol = 0.162dm^3 114g = 0.162dm^3 density = 114g ÷ 0.162dm^3 = 704g/dm^3	[1]
		1dm^3 = 0.083g 24dm^3 = 0.083g x 24dm^3 = 1.992g 1000g = -143000kJ enthalpy change = -14300 ÷ 1000g x 1.992g = -285kJ/mol	[1]
		1mol = -5075kJ no. of mol. of C_8H_{18} = 1000g ÷ 114 = 8.7719mol enthalpy change = 8.7719mol x (-5075kJ) = -44500kJ/kg	[1]
	(b)	Octane fuel is easier to store. Hydrogen is a gas, while octane is a liquid at room temperature and pressure. This makes hydrogen more dangerous and difficult to store. OR Hydrogen is a more energy efficient fuel. Hydrogen has a larger energy content than octane. For 1kg of each fuel, hydrogen releases more energy (i.e. 143000kJ) than octane (i.e. 44500kJ).	[1]
	(c)	cathode: $O_2(g) + 4H^+(aq) + 4e^- \rightarrow 2H_2O\ (l)$	[1]
		anode: $H_2(g) \rightarrow 2H^+(aq) + 2e^-$	[1]
	(d)	On diagram • 1m – energy level of product is lower than that of reactant • 1m – correct labelling of enthalpy change using a one-sided arrow • 1m – correct labelling of activation energy using a one-sided arrow; activation energy is lower for the reaction with catalyst	[3]
	(e)	The conventional simple cell uses two metals of different reactivity, while the lithium-ion battery uses only one metal, i.e. lithium.	[1]
		In the conventional simple cell, the more reactive metal is the anode, while in the lithium-ion cell, graphite anode is used.	[1]
	(f)	The statement is not valid. During charging, electrons and lithium ions move out of the cathode towards the anode. The gain of electrons is a reduction process.	[1]
B9	**(a)**	He rinsed the conical flask with oxalic acid. This error will result in a larger volume of aqueous sodium hydroxide required to neutralise the oxalic acid from the burette.	[1]
	(b)	$H_2A + 2NaOH \rightarrow Na_2A + 2H_2O$ Fr. Eqn.: 1 2 Given : 1.0mol/dm^3 1.6mol/dm^3 25.0cm^3 ?cm^3 0.025mol 0.050mol	[1]
		maximum volume of NaOH = 0.050mol ÷ 1.6mol/dm^3 = 31.3 cm^3	[1]

(c) (i)

	C	H	O
%	26.7	2.20	71.1
A_r	12	1	16
no. of mol.	2.225	2.20	4.44375
÷ 2.2	1	1	2

[1]

∴ empirical formula = $\underline{CHO_2}$ [1]

(ii) $(CHO_2)_n = 90$

$n = 2$

molecular formula = $\underline{C_2H_2O_4}$ [1]

(iii) no. of mol. of oxalic acid = 0.05 ÷ 90 = 0.00055556mol [1]

1 serving = 0.00013227 mol

no. of servings = 0.00055556 mol ÷ 0.00013227 ≈ $\underline{4}$ [1]

B10 Either

(a) (i) $TiCl_4$ is a simple covalent molecule, with weak intermolecular forces between **molecules**. [1]

Based on the information given, $TiCl_4$ has a low boiling point of 136°C. [1]

(ii) Since titanium is a metal and chlorine is a non-metal, the compound formed should be an ionic compound. [1]

[Covalent bonding occurs between non-metals.]

(iii) Since $TiCl_4$ is a neutral molecule, the absence of mobile charged particles prevents the electric current from being carried. [2]

(b) (i) $TiO_2 + 2Cl_2 + 2C \rightarrow TiCl_4 + 2CO$ [1]

(ii) When inhaled, CO combines with haemoglobin in blood, causing the body to be starved of oxygen, leading to death. [1]

(c) (i) $TiCl_4 + 2Mg \rightarrow Ti + 2MgCl_2$ [1]

(ii) Magnesium, being more reactive than titanium, displaces titanium from titanium chloride. [2]

B10 Or

(a) (i) 'Dot-and-cross' diagram of F – Cl – F (covalent) [2]

F

(ii) $4ClF_3 + 6H_2O \rightarrow 12HF + 3O_2 + 2Cl_2$ [2]

(b) (i) 0; -1 [1]

(ii) U is oxidised, as the oxidation state of **uranium** increases from 0 in U to +6 in UF_6. [1]

Cl in ClF_3 is reduced, as the oxidation state of **chlorine** decreases from +3 in ClF_3 to +1 in ClF. [1]

(c) F^- [1]

BrF_3 can conduct electricity due to the presence of mobile **ions**, which allows the electric current to be carried. [1]

Bromine and fluorine are non-conductors of electricity as they both exist as neutral molecules. The absence of mobile charged particles prevents the electric current from being carried. [1]

Name: ..... ( ) Class: Sec 4A

Queenstown Secondary School

Preliminary Examination 2021
Secondary Four Express
Chemistry
6092/01

1 September 2021
Wednesday

Time: 1200 – 1300h
Duration: 1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

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

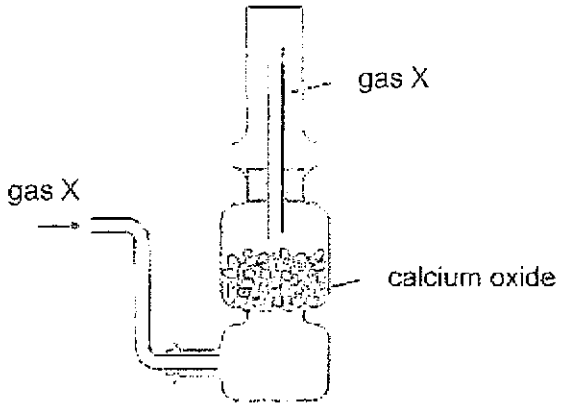
There are **forty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet 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 booklet.
A copy of the Periodic Table is printed on page 20.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **20** printed pages.

1 The experimental set-up below is used to collect a clean, dry sample of gas X. Gas X was given off after ammonium chloride and calcium hydroxide was mixed together and heated in a test-tube. **Gas X = NH_3**



What can be deduced about gas X?

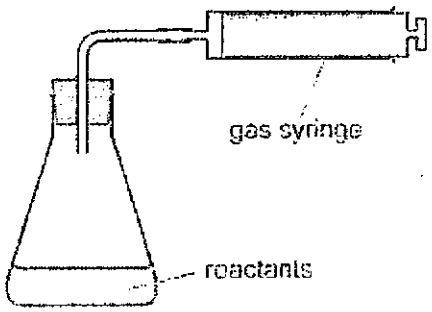
1 It is soluble in water. ✓

2 It is less dense than air. ✓

3 It can also be dried using concentrated sulfuric acid. ✗ **[calcium oxide]**

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

2 The apparatus shown is used to measure the rate of a reaction.



Which of the following reaction rate can be measured using this apparatus?

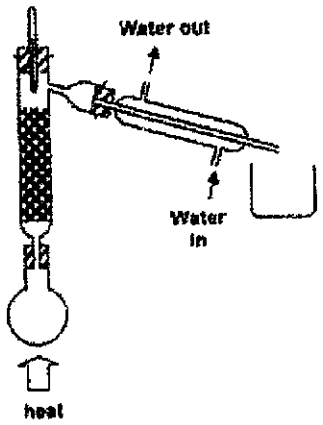
A calcium with dilute hydrochloric acid ✓ **[H_2 produced]**

B copper with dilute nitric acid ✗ **[no reaction]**

C aqueous sodium carbonate with aqueous silver nitrate ✗ **[no gas produced]**

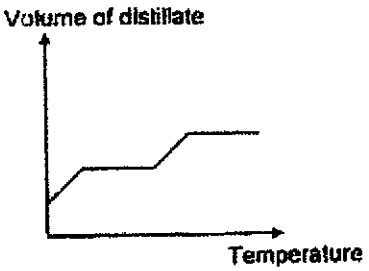
D chlorine with aqueous potassium bromide ✗ **[no gas produced]**

3 The diagram shows the apparatus used to separate liquid R (boiling point 70°C) and ethanol (boiling point 98°C).

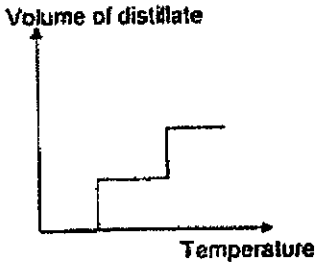


Which graph would be obtained if volume of distillate collected was plotted against temperature?

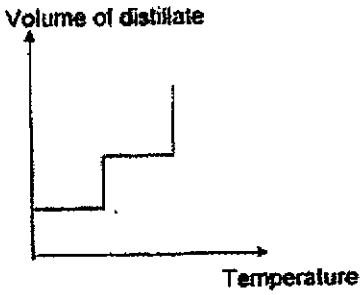
A



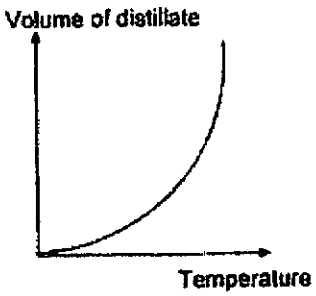
C



B



D



4 Three separations are listed below.

1 Obtaining oil from a mixture of oil and water. **[immiscible liquids]**

2 Obtaining ammonium chloride from a mixture of ammonium chloride and sodium chloride.

3 Obtaining solid copper(II) sulfate **[soluble]** from copper(II) sulfate solution

Which techniques would be involved in separation 1, 2 and 3 respectively?

	1	2	3
A	simple distillation	sublimation	crystallisation
B	simple distillation	crystallisation	filtration
C	separating funnel	sublimation	crystallisation
D	separating funnel	crystallisation	filtration

5 The following observations were recorded after various tests were carried out on a green solid.

- A blue precipitate was observed when aqueous ammonia was added to an aqueous solution of the green solid. **[Cu^{2+}]**
- Effervescence was formed when dilute nitric acid was added to the green solid. Upon adding aqueous barium nitrate to the resultant mixture, no visible reaction was seen. **[CO_3^{2-}]**

What could be the identity of the green solid?

A iron(II) nitrate
B iron(II) sulfate
C copper(II) sulfate
D copper(II) carbonate

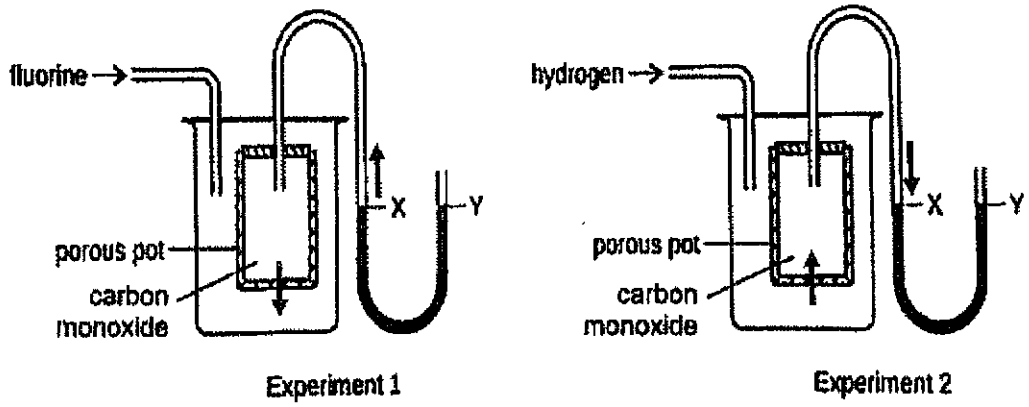
6 In an experiment, 4.0cm^3 of 1.0mol/dm^3 iron(III) sulfate solution is mixed with 4.0cm^3 of 1.0mol/dm^3 sodium hydroxide solution. **[Fe^{3+} (aq) + $3OH^-$ (aq) → $Fe(OH)_3$ (s)]**

excess **limiting**

What does the reaction vessel now contain?

A a green precipitate and an colourless solution
B a green precipitate and an orange solution
C a red-brown precipitate and a colourless solution
D a red-brown precipitate and an orange solution

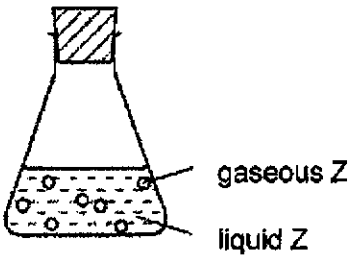
7 Two experimental set-ups used to demonstrate the diffusion of gases are shown in the diagrams below. In each porous pot is carbon monoxide **[M_r = 28]**.
In the first experiment, the gas introduced into the beaker is fluorine gas **[M_r = 38]**, while in the second experiment, hydrogen gas **[M_r = 2]** was introduced.



What changes, if any, to the water levels X and Y would you expect to see in both experiments?

	experiment 1	experiment 2
A	Y is higher than X	X is higher than Y
B	X is higher than Y	Y is higher than X
C	X and Y remain the same	Y is higher than X
D	X and Y remain the same	X and Y remain the same

8 The conical flask contains compound Z which is present in liquid and gaseous states.



Which statement is correct?

A The molecules in gaseous Z slide over each other. * **[move freely]**

B Energy is lost when compound Z changes from gas to liquid.

C Compound Z sublimed from liquid Z to form gaseous Z. * **[solid]**

D Compound Z has a range of boiling points. * **[fixed]**

9 The table gives some statements about atoms and explanations for these statements. Which row shows both a correct statement and a correct explanation for the statement?

	statement	explanation
A	atoms are electrically neutral	same number of electrons and neutrons * **[protons]**
B	atoms of metals tend to gain electrons * **[lose]**	to achieve a full valence shell
C	the mass of an atom is concentrated in its nucleus	presence of protons and neutrons in nucleus
D	the nucleus and electrons repel each other * **[attract]**	nucleus and electrons have opposite charges

10 The table shows information about particles R and S.

particle	number of			
	protons	neutrons	electrons	
R	11 2,8,1	12	10	**positive ion**
S	19 2,8,8,1	20	18	**positive ion**

Which of the following statement is correct for both R and S?

A Both are atoms in the same Group.

B Both are isotopes of the same element.

C Both are positive ions in the same Group.

D Both are positive ions in different Groups.

11 Some properties of substances P, Q, R and S are given in the table.

substance	percentage composition by mass	solid conducts electricity	changes on heating
P	varies	no	solid burns to form carbon dioxide and water
Q	constant	yes	solid burns in air to form an oxide
R	varies	no	solid melts
S	constant	yes	solid decomposes

Which classification of substances is correct?

	element	mixture	compound
A	S, Q	P	R
B	Q	P, R	S
C	S	P	Q, R
D	R	P, Q	S

12 Lithium and fluorine react to form lithium fluoride.

A student writes three statements about the reaction.

1 Lithium atoms lose an electron when they react. ✓

2 Each fluoride ion has one more electron than a fluorine atom. ✓

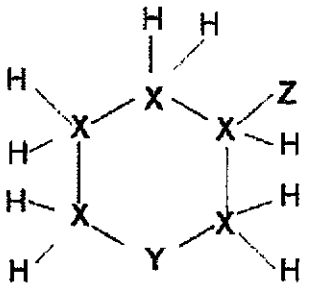
3 Lithium fluoride consists of strong electrostatic forces between atoms. ✗

[ions]

Which statements are correct?

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

13 The compound below is made up of hydrogen and the elements X, Y and Z.



Which statement is **incorrect**?

A Element Z is most likely from Group VII.

B Element X is most likely from Group IV.

C The compound is formed by the losing and gaining of electrons.

*** [sharing]**

D The compound has the molecular formula X_6H_9YZ.

14 Carbon and silicon are both in Group IV of the Periodic Table.
At room temperature, CO_2 is a gas whereas SiO_2 is a solid.

Which statement explains this?

A Covalent bonding is weaker in CO_2.

B Covalent bonds in CO_2 are double bonds and in SiO_2 the covalent bonds are single bonds.

C CO_2 is a covalent compound and SiO_2 is an ionic compound.

D CO_2 is a simple covalent molecule and SiO_2 is a giant covalent molecule.

15 Below are four statements about metals.

1 Metals can conduct electricity. ✓
2 Metals have high melting points, except some metals. ✓
3 Metals contain a lattice of positive ions in the presence of delocalised electrons. ✓
4 Metals require a large amount of energy to overcome the strong covalent bonds between the atoms. * **[forces of attraction between + ions and e⁻]**

Which of the following statements is correct?

A Statement 1 is correct and statement 3 explains statement 1.
B Statement 2 is correct and statement 4 explains statement 2.
C Statement 3 is incorrect and statement 4 is correct.
D All statements are correct but statement 1 does not explain statement 2.

16 Two moles of X decompose rapidly at room temperature to give one mole of oxygen and two moles of bromine. [$2Br_2O \rightarrow O_2 + 2Br_2$]

What is the molecular formula of X?

A BrO_2 **B** Br_2O **C** Br_2O_2 **D** Br_4O_2

17 All ammonium salts produce ammonia gas on heating with sodium hydroxide. Which ammonium salt has the greatest percentage mass of nitrogen?

A NH_4Cl **26.2%** **B** NH_4NO_3 **35%** **C** $(NH_4)_2SO_4$ **21.2%** **D** $(NH_4)_3PO_4$ **28.2%**

18 12.0 g of anhydrous magnesium sulfate combines with 12.6 g of water to form hydrated magnesium sulfate.

What is the formula of the hydrated magnesium sulfate?

A $MgSO_4.9H_2O$ **B** $MgSO_4.7H_2O$ **C** $MgSO_4.5H_2O$ **D** $MgSO_4.3H_2O$

	$MgSO_4$	H_2O
mass	12.0 g	12.6 g
M_r	120	18
mass / M_r	0.1	0.7
÷ 0.1	1	7

19 Upon strong heating, a metal nitrate compound undergoes decomposition according to the following equation:

$$2XNO_3\,(s) \rightarrow 2X\,(s) + 2NO_2\,(g) + O_2\,(g)$$

Complete decomposition of 6.80g of the nitrate gives 480cm^3 of oxygen, measured at room temperature and pressure. What is the relative atomic mass of X?

A 108 B 170 C 216 D 340

$2XNO_3\,(s) \rightarrow 2X\,(s) + 2NO_2\,(g) + O_2\,(g)$

Fr. Eqn.: 6.80g 0.48dm^3

0.04mol 0.02mol

M_r of XNO_3 = 6.80g ÷ 0.04mol = 170

A_r of X = 170 – 14 – 3(16) = 108

20 0.5mol/dm^3 sulfuric acid is added gradually to a flask containing 20cm^3 of 2.0mol/dm^3 sodium hydroxide solution.

What is the total volume of the mixture in the flask when the solution is just neutral?

A 20cm^3 B 40cm^3 C 60cm^3 D 80cm^3

H_2SO_4 + $2NaOH \rightarrow Na_2SO_4 + 2H_2O$

Fr. Eqn.: 0.5mol/dm^3 2.0mol/dm^3

?cm^3 20cm^3

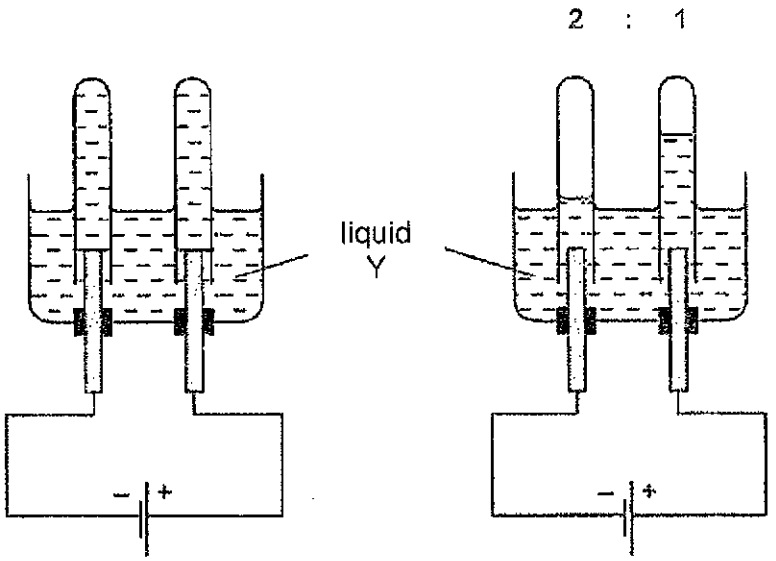
0.02mol 0.04mol

Volume of H_2SO_4 = 0.02mol ÷ 0.5mol/dm^3 = 0.04dm^3 / 40cm^3

21 Magnesium can be produced by electrolysis of molten magnesium chloride, $MgCl_2$.
What are the equations for the reactions that occur at the positive electrode and at the negative electrode? Mg^{2+}, Cl^-

	positive electrode	negative electrode
A	$2Cl^- \rightarrow Cl_2 + 2e^-$	$Mg^{2+} + 2e^- \rightarrow Mg$
B	$4OH^- \rightarrow 2H_2O + O_2 + 4e^-$	$2H^+ + 2e^- \rightarrow H_2$
C	$2Cl^- + 2e^- \rightarrow Cl_2$	$Mg + 2e^- \rightarrow Mg^{2+}$
D	$Mg^{2+} + 2e^- \rightarrow Mg$	$2Cl^- \rightarrow Cl_2 + 2e^-$

22 The diagrams show an electrolysis set-up using inert electrodes.



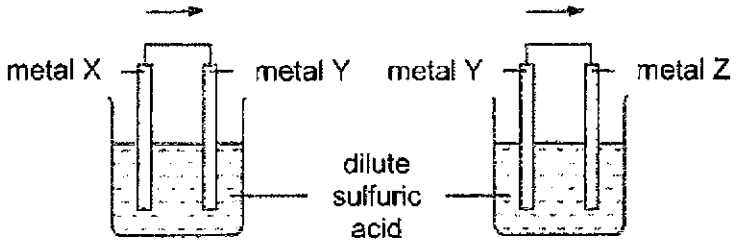
Which could be liquid Y?

1 aqueous magnesium nitrate H^+, OH^-, Mg^{2+}, NO_3^-
2 aqueous copper(II) sulfate H^+, OH^-, Cu^{2+}, SO_4^{2-}
3 concentrated hydrochloric acid H^+, OH^-, Cl^-
4 dilute sulfuric acid H^+, OH^-, SO_4^{2-}

A 1 and 4 only B 2 and 4 only C 1, 2 and 4 only D 1, 3 and 4 only

23 Two cells were set up as shown in the diagram.

The arrows show the direction of electron flow in the external circuits. **X > Y > Z**



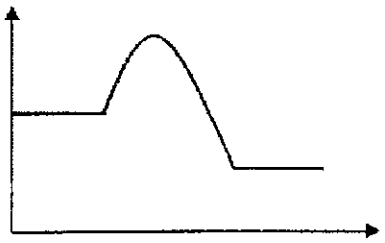
Which set of metals would give the electron flows in the directions shown?

	metal X	metal Y	metal Z
A	Ag	Cu	Zn
B	Ag	Zn	Cu
C	Cu	Zn	Ag
D	Zn	Cu	Ag

24 The reaction between P and Q to produce R is a reversible reaction. The activation energy for the forward reaction is +345 kJ/mol and can be represented as

$$P + Q \rightleftharpoons R \qquad \Delta H = -45 \text{ kJ/mol}$$

The energy profile diagram is shown below. **exothermic**



Which of the following options correctly describes the reverse reaction?

	type of reaction	activation energy (in kJ/mol)	ΔH (in kJ/mol)
A	exothermic	+345	-45
B	endothermic	+390	+45
C	exothermic	-345	-45
D	endothermic	-390	+45

25 Which of the following statements best describes the mechanism of a hydrogen-oxygen fuel cell?

The electrode reactions in a hydrogen-oxygen fuel cell are shown below.

at the positive electrode : $O_2\ (g) + 2H_2O\ (l) + 4e^- \rightarrow 4OH^-\ (aq)$

at the negative electrode : $H_2\ (g) + 2OH^-\ (aq) \rightarrow 2e^- + 2H_2O\ (l)$

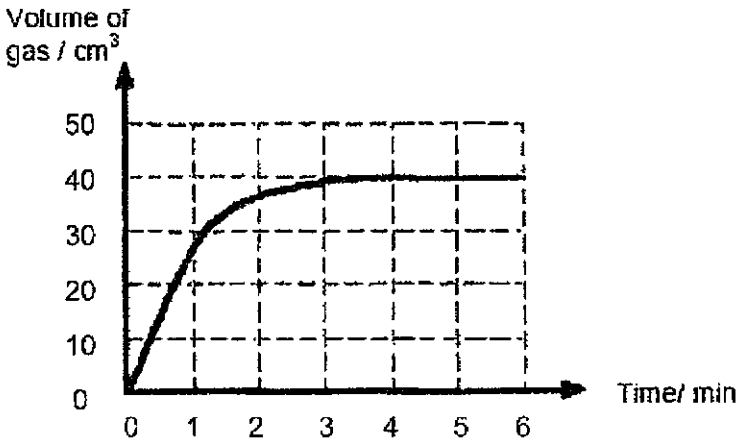
A Electricity is used to provide heat energy.

B Electricity is used to generate hydrogen and oxygen.

C Hydrogen ions react with hydroxide ions to generate electricity.

D Hydrogen and oxygen undergo redox reactions to generate electricity.

26 The rate of reaction between pieces of zinc **[limiting]** and 1.0mol/dm^3 hydrochloric acid **[excess]** was investigated. The total volume of gas produced every minute was recorded over a period of time. The zinc had completely reacted in the reaction and the results are shown in the graph below.



What would be expected if the experiment was repeated using the same mass of zinc and the same volume of 0.5mol/dm^3 hydrochloric acid? **[↓ conc. = ↓ speed]**

	maximum volume of gas produced	time at which maximum volume is obtained
A	40cm^3	less than 4 minutes
B	40cm^3	longer than 4 minutes
C	20cm^3	less than 4 minutes
D	20cm^3	longer than 4 minutes

27 A household bleach contains sodium chlorate(I), NaC*l*O, as its active ingredient. When sodium chlorate(I) is stirred into excess aqueous hydrogen peroxide, the reaction that occurs is represented by the following equation.

$$NaClO\,(aq) + H_2O_2\,(aq) \rightarrow NaCl\,(aq) + O_2\,(g) + H_2O\,(l)$$

+1 -1

Which of the following can be deduced from the reaction?

1 Hydrogen peroxide acts as a reducing agent in this reaction. ✓
2 Hydrogen peroxide acts as an oxidising agent in this reaction. ✗
3 The final solution gives a white precipitate with acidified silver nitrate. ✓ **[C*l*⁻]**
4 The final solution bleaches damp litmus paper. ✗ **[no Cl_2]**

A 1 only **B** 2 only **C** <u>1 and 3</u> **D** 2 and 4

28 Which of the following statements about sulfuric acid is/are true?

1 It is used to make fertilisers. ✓
2 It causes Universal Indicator to turn orange due to the low amount of H^+ ions. ✗ **[red, high]**
3 It reacts with sodium hydroxide to form a soluble salt and hydrogen gas. ✗ **[water]**
4 It reacts with lead(II) carbonate to form an insoluble salt, carbon dioxide and water. ✓

A 1 and 2 only **B** <u>1 and 4 only</u> **C** 2 and 3 only **D** 3 and 4 only

29 Which of the following salts can be prepared using the same method?

A zinc chloride **[soluble – non-SPA]**, calcium sulfate **[insoluble]**
B potassium iodide **[soluble – SPA]**, lead(II) iodide **[insoluble]**
C <u>copper(II) sulfate, lead(II) nitrate</u> **[soluble – non-SPA]**
D potassium nitrate **[soluble – SPA]**, magnesium nitrate **[soluble – non-SPA]**

30 Which of the following are true of Haber Process?

1 Nitrogen is obtained from the cracking of petroleum.
× [fractional distillation of air]

2 1 mole of nitrogen reacts with 3 moles of hydrogen to form ammonia. ✓

3 Unreacted nitrogen and hydrogen are released into the atmosphere.
× [recycled]

4 Finely divided iron provides an alternative pathway with lower activation energy. ✓

A 1 and 2 only **B** 1 and 3 only **C** 2 and 4 only **D** 3 and 4 only

31 The table below shows some information of three elements.

element	P	Q	R
atomic number	10	11	7
	2.8	**2.8.1**	**2.5**

Which of the following statements about the elements is correct?

A P exists as a monatomic element and is used to fill up balloons. **× [Ar]**

B P and R are in the same period as their atoms occupy two electron shells each.

C The compound formed between P and Q has a high melting point.
× [unreactive]

D Q and R form a compound that has a formula of QR_3. **× [Q_3R]**

32 Rubidium, Rb, is an element in the same group of the Periodic Table as lithium, sodium and potassium.

Which statement about rubidium is likely to be correct?

A It forms a manganate with the formula $RbMnO_4$.

B It forms an insoluble hydroxide. **× [soluble]**

C It is obtained by the electrolysis of aqueous rubidium chloride. **× [molten]**

D It reacts slowly with cold water to form an alkaline solution. **× [explosively]**

33 The information below shows the percentage of carbon in two samples of steel, Q and R. Q consists of 60% carbon while R consists of 20% carbon.

[↑ carbon → harder and stronger; more brittle]

Which statement is correct about the two samples of steel?

A Q has higher strength and less brittle than R.

B R has higher strength and more brittle than Q.

C Q has lower strength and more brittle than R.

D R has lower strength and less brittle than Q.

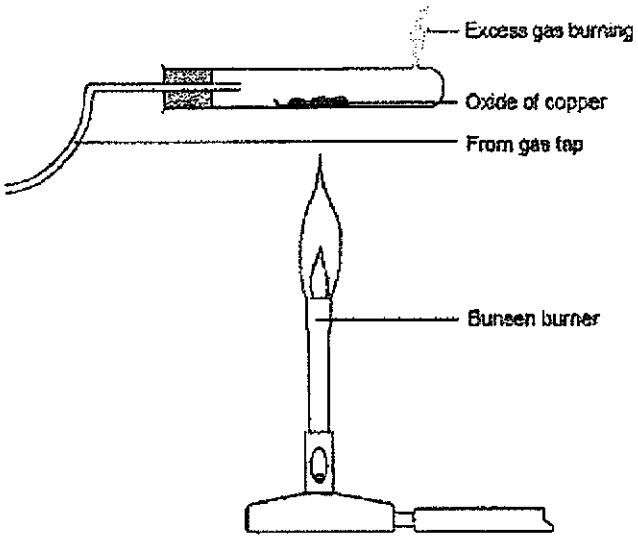
34 The table below provides information on the chemical properties of four metals and some of their compounds.

metal	metal + steam	metal oxide + coke	strong heating of metal carbonate
W	H_2 evolved	oxide reduced	CO_2 evolved
X	H_2 evolved	no visible reaction	no visible reaction
Y	no visible reaction	oxide reduced	CO_2 evolved
Z	H_2 evolved	no visible reaction	CO_2 evolved

Which of the following shows the correct order of reactivity of the metals?

	most reactive	→		least reactive
A	Y	W	Z	X
B	X	Z	W	Y
C	Z	X	W	Y
D	W	X	Y	Z

35 The following set-up is used to study the reduction of an oxide of copper.
The oxide of copper is Cu_2O, which is a red solid. **[$H_2 + Cu_2O \rightarrow H_2O + 2Cu$]**
What would be observed when the reaction has stopped, and what is the purpose of burning the excess gas?



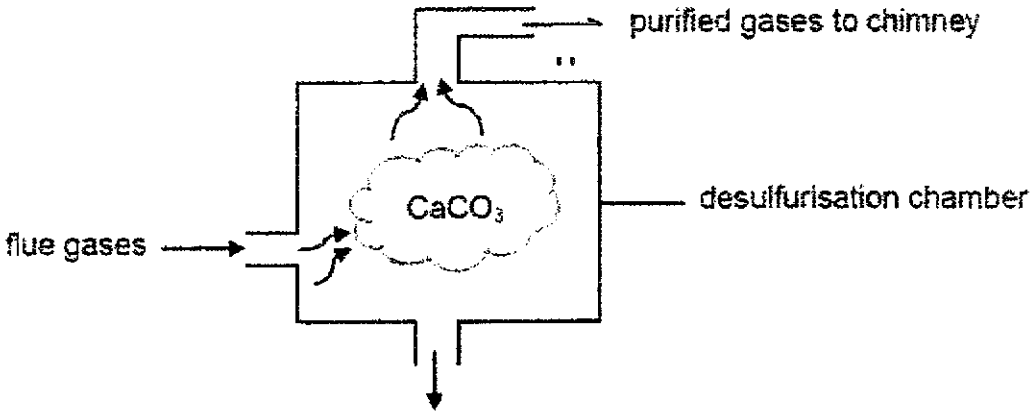
	observation	purpose for burning excess gas
A	red solid turns brown **[Cu]**	hydrogen gas used to reduce oxide is highly flammable
B	red solid remains unchanged	carbon monoxide used to reduce oxide is poisonous
C	red solid turns brown	carbon dioxide is a pollutant
D	red solid turns black	nitrogen dioxide gas used to reduce oxide is a pollutant

36 Which of following reactions does **not** occur in a blast furnace during the extraction of iron?

A $CaO + CO_2 \rightarrow CaCO_3$
B $CaO + SiO_2 \rightarrow CaSiO_3$
C $CO_2 + C \rightarrow 2CO$
D $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

37 The following diagram shows a simplified process of desulfurisation.

[$CaCO_3 + SO_2 \rightarrow CaSO_3 + CO_2$]



Which of the following correctly describes the process?

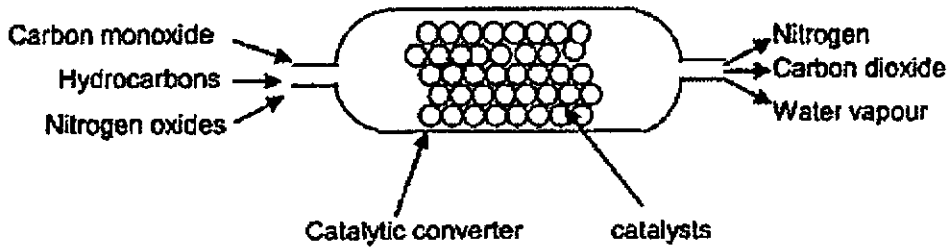
A The purified gases give a white precipitate in limewater. **[CO_2]**

B Carbon monoxide present in the flue gases reacts with $CaCO_3$.

C The purified gases decolourise acidified aqueous potassium manganate(VII).

D The desulfurisation process is a redox reaction.

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



Which process(es) take(s) place in the converter?

1 Hydrocarbons are reduced to form carbon dioxide and water vapour.

2 Carbon monoxide reacts with nitrogen oxides to form carbon dioxide and nitrogen. **[$2CO + 2NO \rightarrow 2CO_2 + N_2$]**

3 Nitrogen oxides react with hydrocarbons to form water vapour and nitrogen.

4 Redox reactions occur. **[CO is oxidised to CO_2; NO is reduced to N_2]**

A 1 and 2 only **B** 2 and 3 only **C** 2 and 4 only **D** 3 and 4 only

39 The average temperature of the Earth has been observed to be increasing gradually.

1 Depletion of ozone layer * [CFCs]
2 Increase in rate of growth of plants and animals *
3 Increase in droughts, wildfires and heavier rainfall
4 Increase in melting of glaciers and ice caps, leading to increase in sea levels

Which of the above describe the environmental effects of an increase in Earth's temperature?

A 1 and 2 only **B** 1, 2 and 3 **C** 3 and 4 only **D** 2, 3 and 4

40 Biodiesel, an alternative fuel made from vegetable oil, can be used as a fuel for vehicles. Although carbon dioxide is released during the combustion of biodiesel, scientists still claim that it is a carbon neutral fuel.

Which is the basis for this claim?

A Biodiesel is not a carbon compound.
B Biodiesel produces less carbon dioxide when it burns.
C Plants release carbon dioxide during respiration.
D Plants absorb carbon dioxide during photosynthesis.

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 106	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: proton (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.)

[Turn over