	Class	Register Number
Name		

6092/01
CHEMISTRY

20/4PE/6092/1

PAPER 1

Wednesday **16 September 2020** **1 hour**

VICTORIA SCHOOL

PRELIMINARY EXAMINATION
SECONDARY FOUR

Additional materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Write your name, class and index number on all the work you hand in.
Do not use staples, paper clips, glue or correction fluid.

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 that 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.

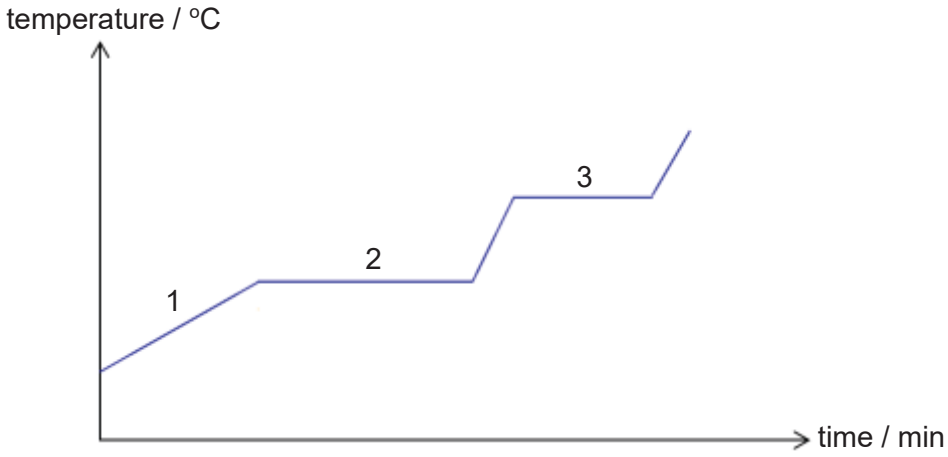
The use of an approved scientific calculator is expected, where appropriate.

A copy of Periodic Table is printed on **page 20**.

Setter: Lyana Y.

This question paper consists of 20 printed pages, including the cover page.

1 The graph below shows the changes in temperature when a mixture containing equal volumes of X (boiling point 78 °C) and Y (boiling point 108 °C) is heated and separated by fractional distillation.



Which of the following describes the concentration of vapours X and Y correctly?

section	concentration of vapours
1	equal X and Y in the distilling flask
2	more X than Y in the condenser
3	more X than Y in the condenser

A 2 only

B 1 and 2 only

C 2 and 3 only

D 1, 2 and 3

2 Which group of substances contains an element, a mixture and a compound?

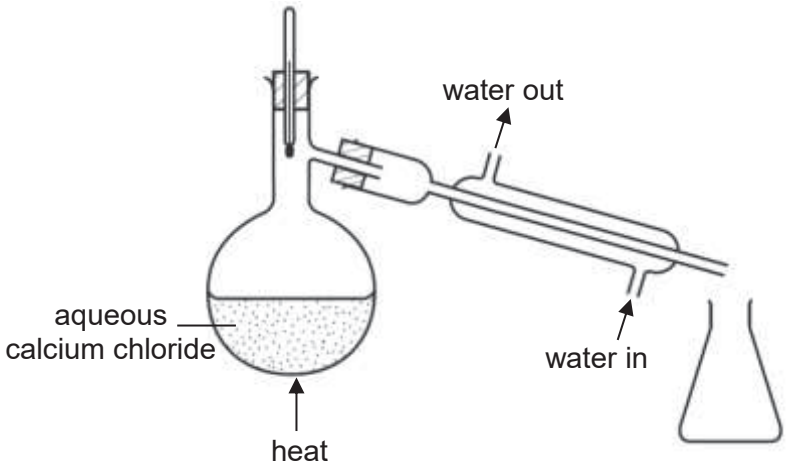
A air, bronze, sodium chloride

B air, sulfur, copper(II) sulfate

C sulfur, magnesium, bronze

D sulfur, copper(II) sulfate, sodium chloride

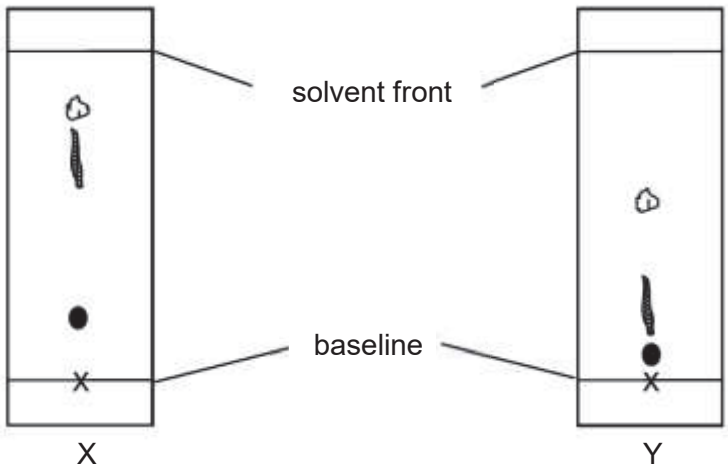
3 Aqueous calcium chloride is distilled as shown in the diagram below.



What is the temperature shown by the thermometer and what is left in the distillation flask?

	temperature reading / °C	final contents of distillation flask
A	97	no residue
B	100	white residue
C	103	no residue
D	106	white residue

4 Two students performed paper chromatography to identify the dyes present in a paint sample. The two chromatograms, X and Y, are shown below.



What is a possible explanation for the difference in the two chromatograms?

A A more concentrated sample was placed on the baseline of chromatogram X.

B A smaller sample size was placed on the baseline of chromatogram Y.

C Different solvents were used for chromatograms X and Y.

D The experiment was performed for a longer period of time for chromatogram X.

5 Which of the following describes the trend of the elements across Period 3 of the Periodic Table?

1 decrease in metallic character

2 increase in atomic radius

3 increase in number of valence electrons

A 2 only

B 1 and 2 only

C 1 and 3 only

D 1, 2 and 3

6 Which of the following statements correctly describes the sub-atomic particles present in a germanium atom, $^{70}_{32}\mathrm{Ge}$?

1 It has the same number of electrons as a $^{79}_{34}\mathrm{Se}^{2+}$ ion.

2 It has the same number of neutrons as a $^{68}_{30}\mathrm{Zn}$ atom.

3 It has twice the number of protons as a $^{32}_{16}\mathrm{S}^{2-}$ ion.

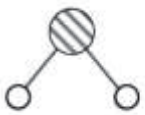
A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 3

7 The structural diagrams of two molecules, X_2Y and ZY_2, are shown below.

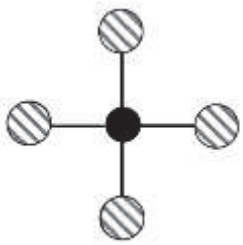


X_2Y

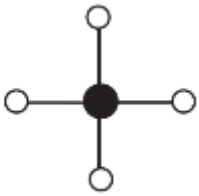
ZY_2

Which of the following represents a molecule of a compound formed between X and Z?

A



B



C

D

8 The formula of the nitride of element X is XN.

What is the formula of a compound formed between X and an oxalate ion, $C_2O_4^{2-}$?

A XC_2O_4

B $X(C_2O_4)_2$

C $X_2(C_2O_4)_3$

D $X_3C_2O_4$

9 Elements X, Y and Z are in the same period of the Periodic Table.

The properties of the oxides formed by these elements are shown below.

oxide X	dissolves in dilute hydrochloric acid
oxide Y	dissolves in aqueous sodium hydroxide
oxide Z	dissolves in both dilute hydrochloric acid and aqueous sodium hydroxide

What is the order of the elements X, Y and Z in increasing atomic number?

A X, Y, Z

B X, Z, Y

C Y, X, Z

D Y, Z, X

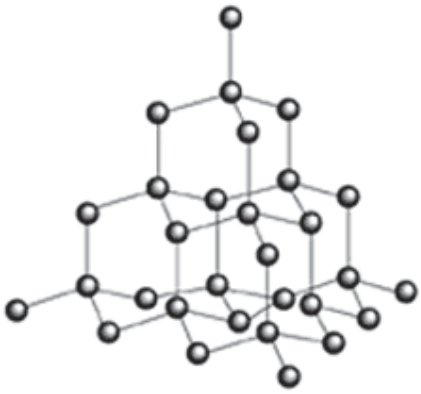
10 The table below shows the electrical conductivities of substances W – Z.

substance	electrical conductivity
W	does not conduct under any conditions
X	conducts only in aqueous solution
Y	conducts in both molten and solid states
Z	conducts in both molten and aqueous states

What are the possible identities of substances W – Z?

	W	X	Y	Z
A	AgCl	S	NaCl	Pb
B	HCl	NaCl	C	AgCl
C	S	HCl	Pb	AgCl
D	S	HCl	Pb	NaCl

11 The diagrams below show the structures of diamond and graphene, made up of carbon atoms in different arrangements.



diamond

graphene

Which of the following shows the correct properties of diamond and graphene?

	diamond	graphene
A	good electrical conductor	poor electrical conductor
B	poor electrical conductor	poor electrical conductor
C	high melting point	high melting point
D	low melting point	high melting point

12 The table below shows the range of colours of an indicator at different pH values.

pH	colour
0 – 2.5	red
2.6 – 5.0	yellow
5.1 – 7.0	orange
7.1 – 14.0	green

Which pair of substances can be distinguished using the indicator above?

A aqueous ammonia and aqueous potassium hydroxide

B dilute hydrochloric acid and dilute sulfuric acid

C dilute hydrochloric acid and water

D water and aqueous potassium chloride

13 Which of the following statements correctly describes two strong acids, HX and H_2Y, of the same concentration?

1 H_2Y has a lower pH than HX.

2 The rate of production of carbon dioxide is faster for H_2Y than HX when equal volumes of both acids are reacted with sodium carbonate.

3 More hydrogen gas is produced for HX than H_2Y when equal volumes of both acids are reacted with excess magnesium.

A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 3

14 The table below shows 3 experiments in which different reactants were added to dilute sulfuric acid to prepare different salts.

experiment	reactant	salt
1	calcium oxide	calcium sulfate
2	zinc oxide	zinc sulfate
3	potassium hydroxide	potassium sulfate

Which experiments will produce a high yield of the salt?

A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 3

15 Which air pollutant is correctly matched with its source and effect?

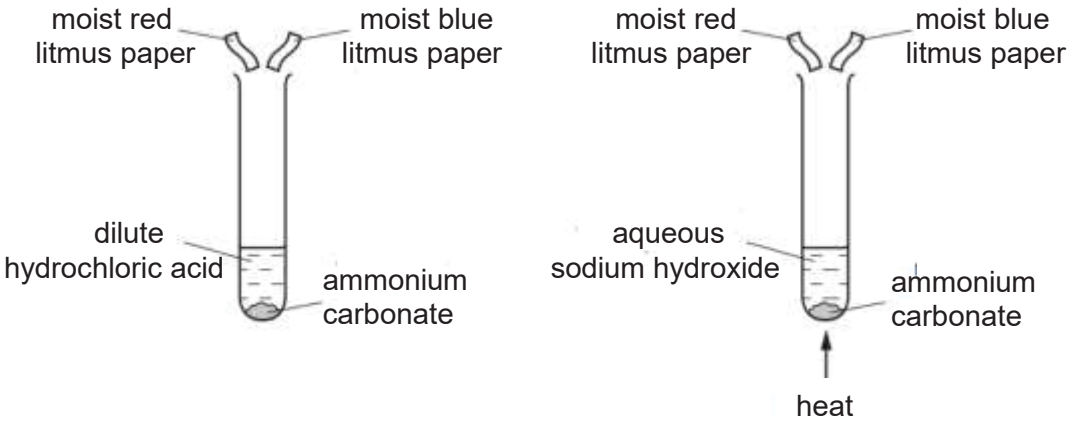
	air pollutant	source	effect
A	carbon monoxide	combustion of fuels	global warming
B	nitrogen dioxide	car engines	acid rain
C	ozone	photochemical smog	ozone layer depletion
D	sulfur dioxide	lightning activity	acid rain

16 Two experiments were carried out as shown in the diagram below.

In experiment 1, ammonium carbonate was added to dilute hydrochloric acid.

In experiment 2, ammonium carbonate was added to aqueous sodium hydroxide.

The gases evolved from both experiments were tested with moist litmus papers.



experiment 1 experiment 2

Which of the following indicates the colours of the moist litmus papers at the end of the reaction?

	1	2
A	blue	blue
B	blue	red
C	red	blue
D	red	red

17 Which of the following is numerically equal to the Avogadro constant?

A number of atoms in 1 mole of hydrogen gas, H_2

B number of electrons in 1 mole of helium gas, He

C number of ions in 1 mole of sodium chloride, NaCl

D number of molecules in 1 mole of oxygen gas, O_2

18 Oxygen gas can be converted into ozone by passing it through an electric discharge.

$$3O_2(g) \rightarrow 2O_3(g)$$

In an experiment, 300 cm^3 of oxygen gas was used but only 10% was converted into ozone.

What is the total volume of gases present at the end of the experiment?

A 200 cm^3

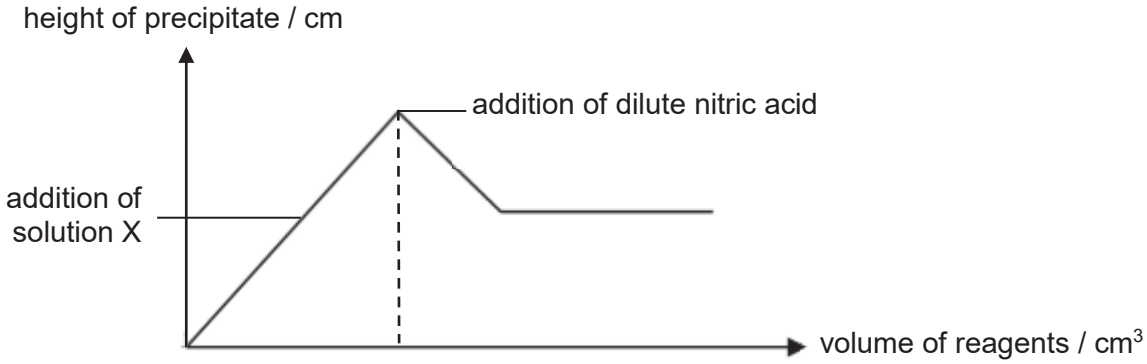
B 210 cm^3

C 290 cm^3

D 300 cm^3

19 The graph below shows how the height of the precipitate formed changes when solution X is gradually added to solution Y.

The height of the precipitate then decreases when dilute nitric acid is added to the mixture.



What can be solution X and the anions present in solution Y?

	solution X	anions in Y
A	aqueous barium nitrate	chloride, carbonate
B	aqueous barium nitrate	iodide, sulfate
C	aqueous silver nitrate	chloride, carbonate
D	aqueous silver nitrate	iodide, sulfate

20 Tin is extracted from its ore, SnO_2, by reducing it with carbon in a furnace. The equation for the reaction is shown below.

$$SnO_2 + 2C \rightarrow Sn + 2CO_2$$

What is the percentage purity of tin ore if 600 g of the tin ore is reduced to produce 82 g of tin?

[A_r of Sn: 119, M_r of SnO_2: 151]

A $\frac{82}{119} \times \frac{151}{600} \times 100$

B $\frac{82}{119} \times \frac{600}{151} \times 100$

C $\frac{119}{82} \times \frac{151}{600} \times 100$

D $\frac{119}{82} \times \frac{600}{151} \times 100$

21 Which equation shows the greatest change in oxidation number for nitrogen?

A $4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$

B $3NO_2 + H_2O \rightarrow 2HNO_3 + NO$

C $2NO + O_2 \rightarrow 2NO_2$

D $4NH_3 + 6NO \rightarrow 5N_2 + 6H_2O$

22 Hydrogen peroxide was added separately to aqueous potassium iodide and acidified potassium manganate(VII).

The iodide ions were oxidised and the manganate(VII) ions were reduced.

Which of the following shows the correct colour changes that had taken place?

	potassium iodide	potassium manganate(VII)
A	brown to colourless	orange to green
B	brown to colourless	purple to colourless
C	colourless to brown	orange to green
D	colourless to brown	purple to colourless

23 The table below shows the results when halogens X, Y and Z are added to different halide solutions containing X^-, Y^- and Z^- ions.

halogen	X^-(aq)	Y^-(aq)	Z^-(aq)
X_2	-	no reaction	no reaction
Y_2	X_2 formed	-	Z_2 formed
Z_2	X_2 formed	no reaction	-

Which of the following shows the halide ions in decreasing order of their strength as reducing agents?

A X^-, Y^-, Z^-

B X^-, Z^-, Y^-

C Y^-, Z^-, X^-

D Z^-, X^-, Y^-

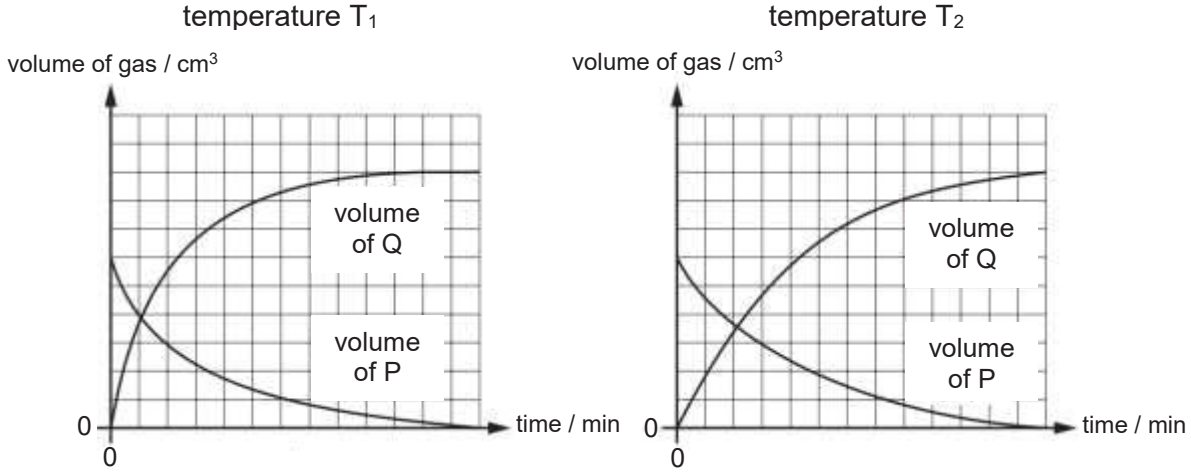
24 Which of the following substances is likely to be a transition metal?

	melting point / °C	density / g cm^{-3}	number of chlorides
A	-7	3.10	2
B	113	2.07	1
C	1083	8.92	2
D	1521	1.12	1

25 Gas P decomposes to form gas Q as shown in the equation below.

$$xP \rightarrow yQ$$

Two experiments are conducted to investigate how different temperatures affect the rate of decomposition of gas P. The results of the experiments are shown below.



Which of the following is correct?

	x	y	temperature
A	2	3	T_1 is higher than T_2
B	2	3	T_2 is higher than T_1
C	3	2	T_1 is higher than T_2
D	3	2	T_2 is higher than T_1

26 The volume of gas produced from the reaction between 0.400 g of powdered magnesium and 100 cm^3 of 0.100 mol dm^{-3} dilute hydrochloric acid was recorded at regular intervals as shown in the table below.

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

time / s	30	60	90	120	150	180	210	240
volume of gas / cm^3	44	70	88	101	110	116	120	120

Which of the following explains the reaction correctly?

	number of collisions over time	end of reaction
A	fewer collisions between reacting particles	magnesium is used up
B	fewer collisions between reacting particles	hydrochloric acid is used up
C	more collisions between reacting particles	magnesium is used up
D	more collisions between reacting particles	hydrochloric acid is used up

27 Some reactions and bond energy values are shown in the table below.

1 $Br_2 \rightarrow 2Br$

2 $2Cl \rightarrow Cl_2$

3 $CH_3 + Cl \rightarrow CH_3Cl$

4 $CH_4 \rightarrow CH_3 + H$

bond	bond energy / kJ mol^{-1}
C – H	410
C – Cl	340
Cl – Cl	244
Br – Br	193

What is the order of the enthalpy change of the reactions from the most exothermic to the most endothermic?

A 1, 2, 3 ,4

B 2, 3, 4, 1

C 3, 2, 1, 4

D 4, 1, 2, 3

28 Ammonia gas is produced industrially during the Haber Process.

Which of the following statements about the Haber Process is not correct?

A One of the reactants is obtained from liquefied air.

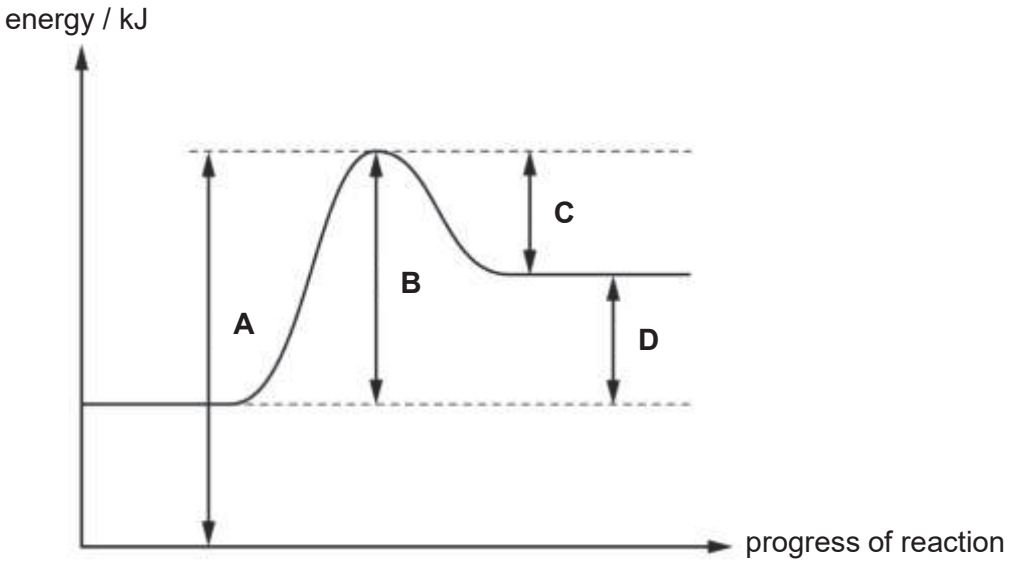
B The optimum pressure for the reaction is 450 atm.

C The catalyst remains unchanged at the end of the reaction.

D The reaction is reversible.

29 The diagram below shows the energy profile diagram of a reaction.

Which arrow represents the activation energy of an exothermic reaction?



30 Iron is extracted from its ore using the blast furnace.

Which of the following statements about the blast furnace is not correct?

A Carbon monoxide is the reducing agent in the extraction of iron.

B Limestone is added to remove the sand present in iron ore.

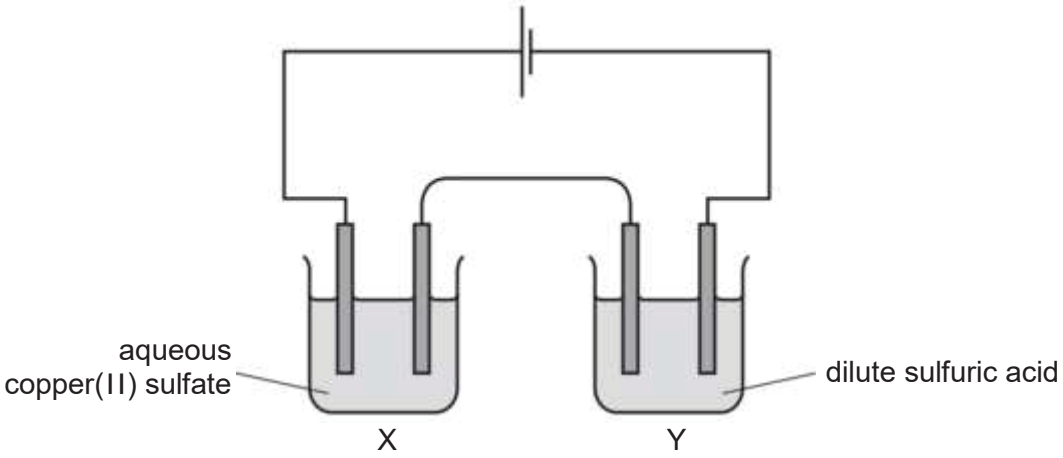
C Molten slag is tapped off from the bottom of the furnace as it is denser.

D Nitrogen is one of the waste gases which escapes from the furnace.

31 Which of the following does not match the type of steel to its use?

	type of steel	use
A	low carbon steel	car bodies
B	low carbon steel	knives
C	stainless steel	cutlery
D	stainless steel	surgical instruments

32 The diagram below shows an electrolysis experiment using inert electrodes.



Which of the following indicates the concentration of the electrolytes in X and Y after some time?

	X	Y
A	unchanged	unchanged
B	unchanged	changes
C	changes	unchanged
D	changes	changes

33 Samples of solid magnesium carbonate were placed in crucibles X and Y.

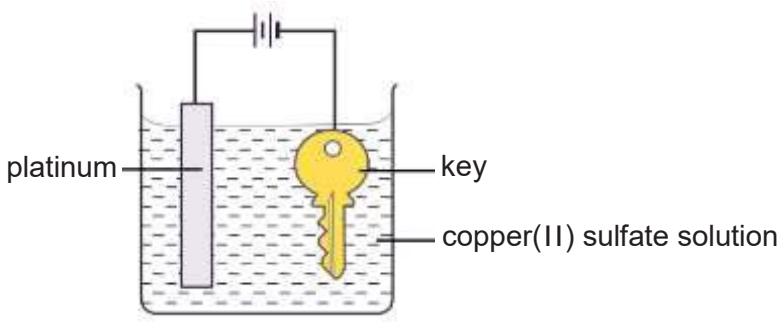
Crucible X was heated strongly until there was no further change in mass while crucible Y was not heated.

Dilute hydrochloric acid was then added to both crucibles.

Which of the following describes the observations in crucibles X and Y?

	X	Y
A	effervescence	effervescence
B	effervescence	no effervescence
C	no effervescence	effervescence
D	no effervescence	no effervescence

34 The diagram below shows the electroplating of a metal key using a platinum electrode.



The mass of the key before and after electroplating is shown in the table below.

mass of key before electroplating / g	23.6
mass of key after electroplating / g	24.4

What is the volume of gas liberated at the platinum electrode?

A 75 cm^3

B 150 cm^3

C 300 cm^3

D 600 cm^3

35 The table below shows the reactions of four metals, P, Q, R and S, with steam, dilute hydrochloric acid and cold water.

metal	reaction with		
	steam	dilute hydrochloric acid	cold water
P	no	yes	no
Q	yes	yes	yes
R	yes	yes	no
S	no	no	no

What is the arrangement of the four metals in decreasing order of reactivity?

A S, P, R, Q

B S, R, P, Q

C Q, P, R, S

D Q, R, P, S

36 The table below shows the changes in mass of an iron bar when it is placed in solutions X and Y.

solution	initial mass of iron bar / g	mass of iron bar after 20 minutes / g
X	6	5
Y	6	5

What are possible identities of solutions X and Y?

	X	Y
A	copper(II) sulfate	silver nitrate
B	dilute hydrochloric acid	sodium chloride
C	iron(II) chloride	calcium chloride
D	magnesium chloride	dilute sulfuric acid

37 The diagram below shows a boat made from iron.

Some magnesium blocks are attached to the iron below the water line.

How does the magnesium stop the iron boat from rusting?

A Magnesium forms an alloy with the iron.

B Magnesium corrodes in preference to the iron.

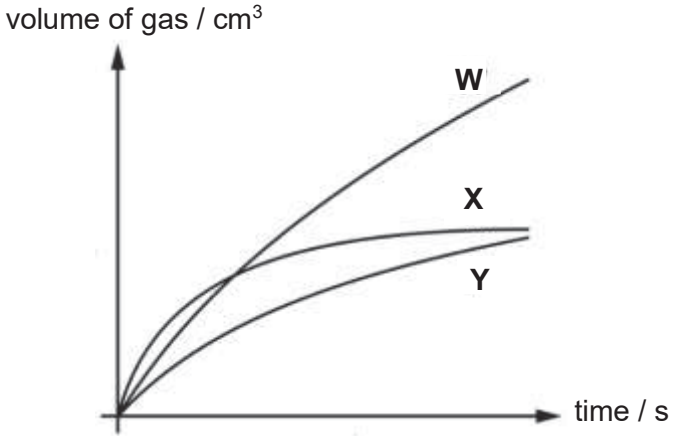
C Magnesium prevents oxygen in the water from reacting with iron.

D Magnesium reacts to form a protective coating of magnesium oxide on the iron.

38 Three different experiments were conducted by reacting excess magnesium with equal volumes of dilute sulfuric acid.

experiment	reaction conditions
1	magnesium strip
2	magnesium powder
3	magnesium strip, acid concentration doubled

For each experiment, the volume of hydrogen gas produced was measured. The graphs for the three experiments are shown below.

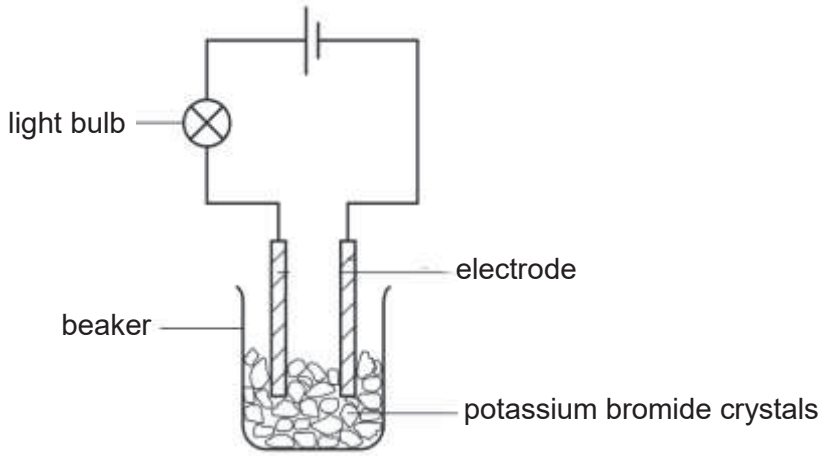


Which of the following shows the graphs of the experiments 1, 2 and 3?

	1	2	3
A	W	X	Y
B	X	Y	W
C	Y	W	X
D	Y	X	W

39 The bulb in the set-up below did not light up when potassium bromide crystals were used.

The bulb lighted up when distilled water was added to the beaker.



Which of the following statements best explains the above?

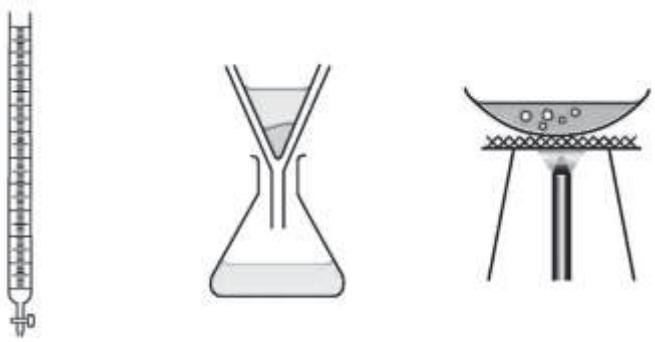
A Potassium bromide dissolves to form delocalised mobile electrons in the electrolyte.

B Potassium bromide dissolves to form mobile ions in the electrolyte.

C Water dissociates fully to form mobile ions in the electrolyte.

D Water molecules move to conduct electricity in the electrolyte.

40 Which apparatus is necessary to prepare a pure and dry sample of copper(II) sulfate crystals?



1 2 3

A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 3

End of Paper

The Periodic Table of Elements

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

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

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

	Class	Register Number
Name		

6092/02
CHEMISTRY

20/4PE/6092/2

PAPER 2

Wednesday **2 September 2020** **1 hour 45 minutes**

NIL SINE LABORE

VICTORIA SCHOOL

PRELIMINARY EXAMINATION
SECONDARY FOUR

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft 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.

The number of marks is given in brackets [ ] at the end of each question or part question.

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

A copy of Periodic Table is printed on **page 20**.

Section A	**/ 50**
Section B	**/ 30**
Total	**/ 80**

Deductions	
Presentation	
Significant Figures	
Units	

Setters: F. Yeo & Ong L.B.

This question paper consists of 20 printed pages, including the cover page.

[Turn Over

Section A (50 marks)

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

A1 Choose from the following list of substances to answer the questions below.

calcium chloride	**lead(II) chloride**	**copper(II) chloride**
graphite	**hydrochloric acid**	**platinum**
copper	**sodium**	**lead**

Each substance can be used once, more than once, or not at all.

(a) Which molecule has a giant structure?

.....[1]

(b) Which substance only conducts electricity in its molten state?

.....[1]

(c) Which substances produce gases at both electrodes when they are electrolysed in their aqueous states with inert electrodes?

.....[1]

(d) Which substances show changes in pH when their concentrated solutions are electrolysed with inert electrodes?

.....[1]

(e) What is the observation of the electrolyte when aqueous copper(II) chloride is electrolysed using copper electrodes?

.....[1]

(f) Fill in the blanks below with one substance each for inert and reactive electrodes.

inert electrode	reactive electrode

[1]

[Total: 6]

A2 Silver dichromate, $Ag_2Cr_2O_7$, is a red insoluble salt.

Silver dichromate can be made by reacting silver nitrate solution with ammonium dichromate solution as shown by the equation below.

$$2AgNO_3 + (NH_4)_2Cr_2O_7 \rightarrow 2NH_4NO_3 + Ag_2Cr_2O_7$$

(a) Describe how you can obtain pure and dry solid silver dichromate after mixing silver nitrate solution and ammonium dichromate solution.

.....

.....

.....[2]

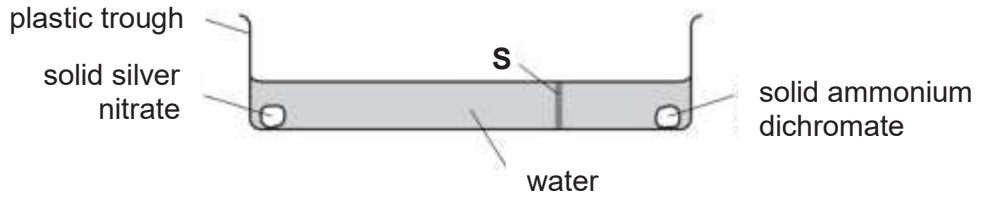
(b) **(i)** Deduce the oxidation state of chromium in $Ag_2Cr_2O_7$.

.....[1]

(ii) Write the ionic equation with state symbols for the formation of silver dichromate in this reaction.

[2]

(c) The apparatus shown below is set up.



After five minutes, a red solid appeared at the position marked **S** on the diagram.

(i) Explain why a red solid appeared at the position marked **S**.

.....

.....

.....[2]

(ii) The experiment is then repeated at a higher temperature.

What effect, if any, would this have on the time taken for the red solid to appear?

Explain your answer.

.....

.....[1]

[Total: 8]

A3 Flerovium, Fl (atomic number: 114) was first made in research laboratories in 1998.

(a) Flerovium was made by bombarding atoms of plutonium, Pu (atomic number: 94), with atoms of element **Z**.

- The nucleus of one atom of plutonium combined with the nucleus of one atom of element **Z**.
- This formed the nucleus of one atom of flerovium.

Suggest the identity of element **Z**.

.....[1]

(b) Fill in the missing information about an atom of flerovium.

number of electron shells	number of outer shell electrons

[1]

(c) Two isotopes of flerovium are ^{286}Fl and ^{289}Fl.

State a similarity and difference between the nuclei of the two isotopes.

.....

.....

.....[2]

(d) Only a relatively small number of atoms of flerovium has been made in the laboratory and the properties of flerovium have not yet been investigated.

It has been suggested that flerovium behaves like a typical metal.

(i) Draw a labelled diagram to show the type of bonding in flerovium.

[2]

(ii) State a physical property of flerovium.

.....[1]

(iii) Suggest a chemical property of flerovium oxide.

.....[1]

[Total: 8]

A4 The Alhambra is a beautiful monument in Granada, Spain. It comprises of buildings made of limestone, $CaCO_3$, with a river filled with aquatic life near it.

The life of this monument can be preserved by treatment with an aqueous mixture of barium hydroxide and urea, $CO(NH_2)_2$. As this aqueous mixture soaks into the porous limestone structures, the urea slowly reacts with water to form ammonia and carbon dioxide. The carbon dioxide that is released reacts with aqueous barium hydroxide, forming barium carbonate.

The solubility of the sulfates and carbonates of calcium and barium are shown below.

substance	$CaCO_3$	$CaSO_4$	$BaCO_3$	$BaSO_4$
solubility in water / mol dm^{-3}	1.5×10^{-4}	4.6×10^{-2}	9.0×10^{-5}	9.4×10^{-6}

(a) (i) Use information from the table to explain why having a layer of barium carbonate on the monument will help to preserve the life of the limestone monument.

.....

.....[1]

(ii) The layer of barium carbonate on the surface of the treated monument can react with sulfur dioxide in the air to form a layer of barium sulfate and carbon dioxide.

Will the above reaction speed up or slow down corrosion of the monument?

Use information from the table to explain your answer.

.....

.....[2]

(b) Urea reacts with water to form ammonia and carbon dioxide.

(i) Write the equation for this reaction.

[1]

(ii) Environmentalists are concerned when ammonia and carbon dioxide are produced near the river.

Explain why.

.....

.....

.....

.....

.....[3]

(c) Over time, the Alhambra monument is still corroded despite the preservation method used.

Suggest why.

……

……[1]

[Total: 8]

A5 Paracetamol, the active drug ingredient in Panadol, is commonly used to reduce fever and relief pain. Based on recommended dosages, an adult should not take more than 4 g of paracetamol daily.

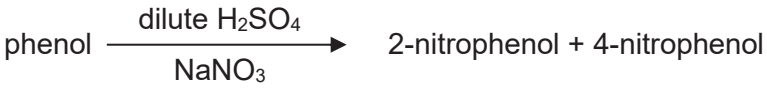
(a) A sample of paracetamol was found to contain 63.6% of carbon, 5.9% of hydrogen, 9.3% of nitrogen and 21.2% of oxygen by mass.

Show, by means of calculation, that the empirical formula of paracetamol is $C_8H_9NO_2$.

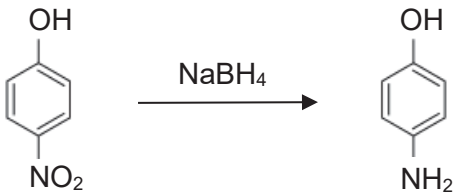
[2]

(b) Paracetamol can be synthesized in the laboratory via a three-step process.

Step 1:



Step 2:



4-nitrophenol ($C_6H_5NO_3$) 4-aminophenol (C_6H_7NO)

Step 3: $C_6H_7NO + C_4H_6O_3 \rightarrow C_8H_9NO_2 + C_2H_4O_2$

4-aminophenol paracetamol ethanoic acid

(i) Suggest why the yield of paracetamol in the laboratory is less than 50%.

.....

.....[1]

(ii) Explain why $NaBH_4$ acts as a reducing agent in step 2.

.....

.....[1]

(iii) One Panadol tablet contains 500 mg of the active ingredient paracetamol.

Calculate the mass of 4-aminophenol required to synthesize 8 Panadol tablets.

[3]

(iv) How can the purity of the synthesized paracetamol be tested?

.....

.....[1]

(v) Explain, in terms of bonding, why paracetamol is a solid but ethanoic acid is a liquid at room temperature and pressure.

.....

.....

.....

.....[2]

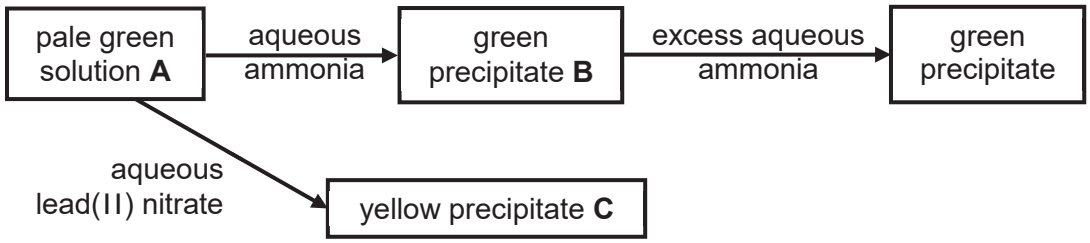
(c) The correct dosage of paracetamol for children varies according to a child's weight. However, a child weighing 10 kg should only consume a maximum of 600 mg of paracetamol in a day.

Given that a bottle of Panadol syrup contains 120 mg of paracetamol per 5 ml of syrup, calculate the correct dose of Panadol syrup (in ml) that should be given every 6 hours for a 10 kg child.

[2]

[Total: 12]

A6 Study the reaction scheme below and answer the questions that follow.



(a) Identify the unknown substances **A**, **B** and **C**.

A: ……

B: ……

C: …… [3]

(b) Describe what will be observed when green precipitate **B** is left to stand.

…….....…….. [1]

(c) Chlorine gas is bubbled into two solutions, solution **A** and aqueous hydrogen peroxide.

(i) Describe and explain what will be observed when chlorine gas is bubbled into solution **A**.

...……

...……

...……[2]

(ii) The reaction between chlorine gas and hydrogen peroxide is shown below.

$$Cl_2 + H_2O_2 \rightarrow 2HCl + O_2$$

Explain, in terms of oxidation states, why this is a redox reaction.

...……

...……

...……[2]

[Total: 8]

Section B (30 marks)

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.

B7 Hydrogen Halides

Hydrogen halides are diatomic covalent molecules with the formula H**X**, where **X** is one of the halogens: fluorine, chlorine, bromine or iodine. Hydrogen halides are colourless gases that dissolve in water to form acids which are commonly known as hydrohalic acids.

$$H\mathbf{X} \rightleftharpoons H^+ + \mathbf{X}^-$$

Strength of Acids

A strong acid usually records a low pH of about 0 to 3. However, this is not always the case as pH is simply a measure of the concentration of hydrogen ions in solution, not the strength of an acid. Hence, even a strong acid can have a pH value near 7 if its concentration is very low. For instance, a 1.00×10^{-6} mol dm^{-3} solution of dilute hydrochloric acid has a pH of 6. The lower the concentration of hydrogen ions in the solution, the higher the pH and vice versa.

pH can be calculated using the formula below:

$$pH = -\log_{10}[H^+]$$

where $[H^+]$ = concentration of hydrogen ions in mol dm^{-3}

Acid Dissociation Constant, K_a

The measure of the strength of an acid can be quantified using the acid dissociation constant, K_a. The larger the K_a value, the greater the extent of the dissociation of the acid molecules in solution and hence the stronger the acid. Weak acids typically have K_a values below 1 while strong acids have K_a values above 1.

The K_a of a monobasic acid, HX, can be calculated using the following formula:

$$K_a = \frac{[H^+][X^-]}{[HX]} = \frac{[H^+]^2}{[HX]}$$

where $[H^+]$ = concentration of hydrogen ions in mol dm^{-3}
$[\mathbf{X}^-]$ = concentration of halide ions in mol dm^{-3}
$[H\mathbf{X}]$ = concentration of hydrohalic acid in mol dm^{-3}

pK_a can be calculated in the same way as pH which is shown below:

$$pK_a = -\log_{10}K_a$$

Table 1 below shows the acid dissociation constants of some hydrohalic acids.

Table 1

substance	K_a / mol dm^{-3}	pK_a
hydrofluoric acid, HF	6.8×10^{-4}	3.2
hydrochloric acid, HCl	1.3×10^{6}	-6.1
hydrobromic acid, HBr		
hydroiodic acid, HI	3.2×10^{9}	-9.5

Data extracted from: https://depts.washington.edu/eooptic/links/acidstrength.html

Bond Energy

Bond energy is a measure of the strength of a covalent bond. It is defined as the amount of energy required to break apart one mole of molecules into its constituent atoms.

Table 2 below shows the bond energy of hydrogen halides, H**X**.

Table 2

bond	bond energy / kJ mol^{-1}
H-F	562
H-Cl	431
H-Br	366
H-I	299

(a) Explain why weak acids typically have K_a values below 1.

……

……[1]

(b) Hydrofluoric acid is a weak acid.

(i) Calculate the concentration of H^+ ions in a 0.100 mol dm^{-3} solution of dilute hydrofluoric acid.

[1]

(ii) Hence, calculate the pH of a 0.100 mol dm^{-3} solution of dilute hydrofluoric acid.

[1]

(c) **(i)** Using Table 1, state the relationship between K_a and pK_a.

……[1]

(ii) Hence, predict the pK_a value for hydrobromic acid, HBr.

……[1]

(d) **(i)** Using Table 1, describe the trend in the strength of the hydrohalic acids down Group VII.

……

……[1]

(ii) Using the bond energies in Table 2, explain your answer in **(d)(i)**.

……

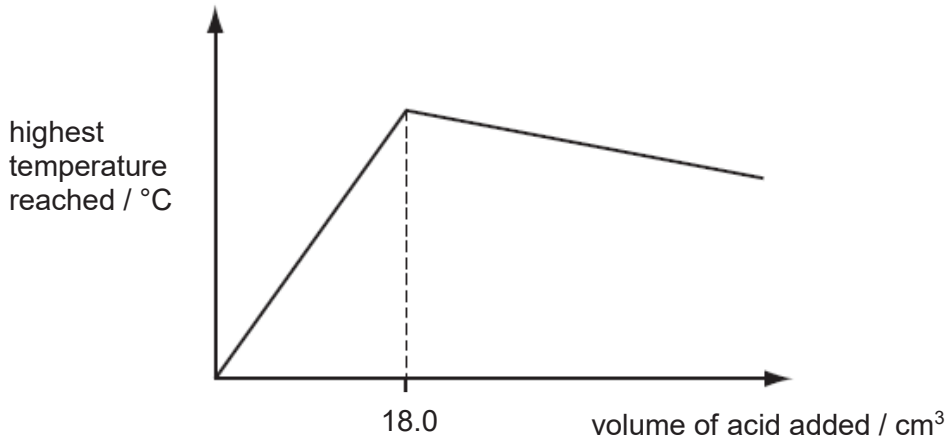
……

……

……[2]

(e) A solution of aqueous sodium hydroxide was placed in a beaker and the temperature of the solution was measured. 1.00 cm^3 portions of dilute hydroiodic acid were added successively into the beaker, with the highest temperature of the mixture reached measured after each addition.

The graph below shows the results of the experiment.



(i) Explain the shape of the graph above, stating clearly the significance of the volume "18.0 cm^3" in your answer.

.....

.....

.....

.....

.....

.....[3]

(ii) The experiment was repeated using dilute hydrochloric acid instead of hydroiodic acid, with all the other conditions kept constant. The same results were obtained.

Suggest why the temperature rise measured is the same for both experiments.

.....

.....[1]

[Total: 12]

B8 Zinc is used to make alloys and in the construction of dry cells (batteries).

Zinc can be obtained from zinc oxide in a two-step process as shown below.

Step 1: aqueous zinc sulfate is made from zinc oxide

Step 2: aqueous zinc sulfate is electrolysed with carbon electrodes to obtain zinc

(a) Name the reagent which reacts with zinc oxide to form zinc sulfate.

.....[1]

(b) Complete the following for the electrolysis of aqueous zinc sulfate.

(i) Write the ionic equation happening at the anode.

[1]

(ii) What is the resulting electrolyte formed?

.....[1]

(iii) Besides electrolysis, suggest another method to extract zinc from zinc oxide.

.....[1]

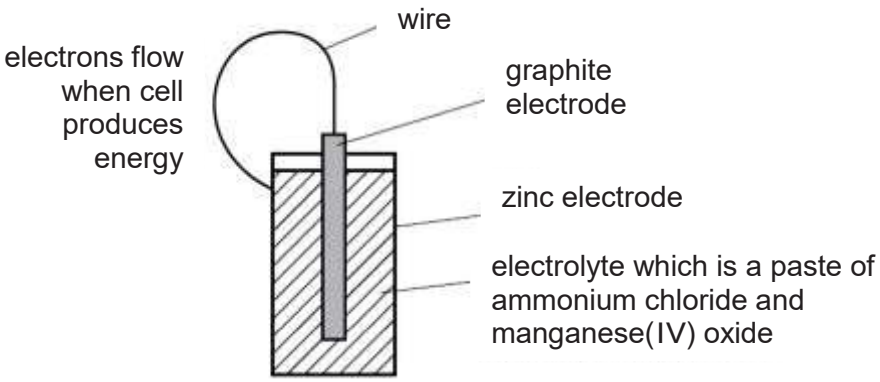
(c) A dry cell (battery) has a central rod, usually made of graphite.

This is the positive electrode which is surrounded by the electrolyte, typically a paste of ammonium chloride and manganese(IV) oxide, all of which are in a zinc container which is the negative electrode.

The following ionic equations occur at the electrodes in a dry cell.

positive electrode: $2NH_4^+(aq) + 2MnO_2(s) + 2e^- \rightarrow Mn_2O_3(s) + 2NH_3(g) + H_2O(l)$

negative electrode: $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^-$



(i) Draw an arrow on the diagram to indicate the direction of electron flow. [1]

(ii) Suggest why the electrolyte is a paste instead of solid.

.....

.....[1]

(iii) Suggest why is there no gas built up in the dry cell.

.....

.....[1]

(iv) Give the overall equation for the reaction.

[1]

[Total: 8]

EITHER

B9 Standard electrode potentials (E°) are also known as reduction potentials. They measure how easily a substance gains electrons, or how easily a substance is reduced.

The E° values for some substances are shown below:

$Mg^{2+}(aq) + 2e^- \rightleftharpoons Mg(s)$	E° = − 2.38 V
$Zn^{2+}(aq) + 2e^- \rightleftharpoons Zn(s)$	E° = − 0.76 V
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	E° = 0.00 V
$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s)$	E° = + 0.34 V
$Ba^{2+}(aq) + 2e^- \rightleftharpoons Ba(s)$	E° = − 2.90 V
$Co^{2+}(aq) + 2e^- \rightleftharpoons Co(s)$	E° = − 0.28 V

The more positive the E° value, the more likely the forward reaction takes place and the more easily the substance is reduced.

Conversely, the more negative the E° value, the more likely the reverse reaction takes place and the more easily the substance is oxidised.

(a) Deduce the relationship between the E° value and reactivity of metals.

……..…….. [1]

(b) A piece of zinc metal was added to a colourless solution of barium nitrate in test tube **A** while a piece of zinc metal was added to a pink solution of cobalt(II) nitrate in test tube **B**.

By writing relevant equation(s), describe what will be observed in the two test tubes.

……..……

……..……

……..……

……[3]

(c) Will barium carbonate require a higher or a lower temperature than cobalt(II) carbonate to decompose?

Explain your answer.

……..……

……..……

……[2]

(d) The reactions of two unknown metals **X** and **Y** are given in the table below.

metal **X**	No visible reaction observed between metal **X** and acid. Metal **X** displaces copper from its salt solution.
metal **Y**	Metal **Y** reacts with both cold water and steam. Magnesium displaces metal **Y** from its salt solution.

Use the information above to predict the E° values of metal **X** and metal **Y**.

metal **X**: ……

metal **Y**: …… [2]

(e) Complete the 'dot-and-cross' diagram to represent the bonding in zinc hydride.

The zinc ion has already been drawn for you.

[2]

[Total: 10]

OR

B9 Three test tubes contain the following acid solutions:

Test tube **A**: 3.00 cm^3 of 1.00 mol dm^{-3} dilute nitric acid

Test tube **B**: 3.00 cm^3 of 1.00 mol dm^{-3} dilute ethanoic acid

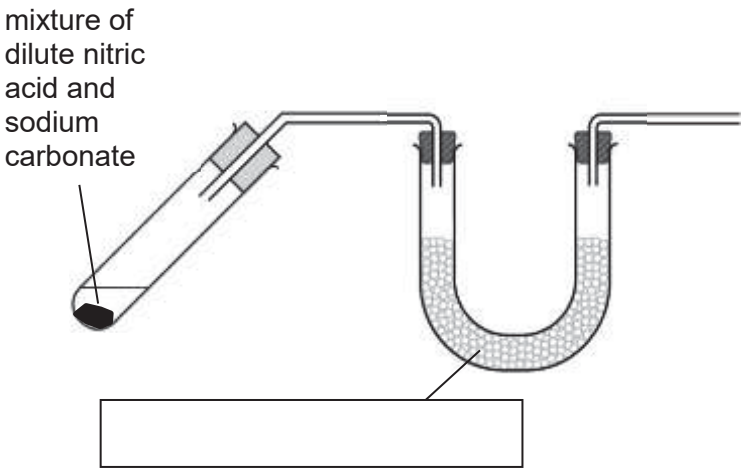
Test tube **C**: 3.00 cm^3 of 1.00 mol dm^{-3} dilute sulfuric acid

Excess powdered sodium carbonate was added to each test tube and the volume of carbon dioxide gas produced was measured over time.

(a) What observation shows that powdered sodium carbonate was added in excess?

……..…….. [1]

(b) **(i)** Complete the diagram below to show the chemical and apparatus required to collect and measure a dry sample of the gas produced in test tube **A**.



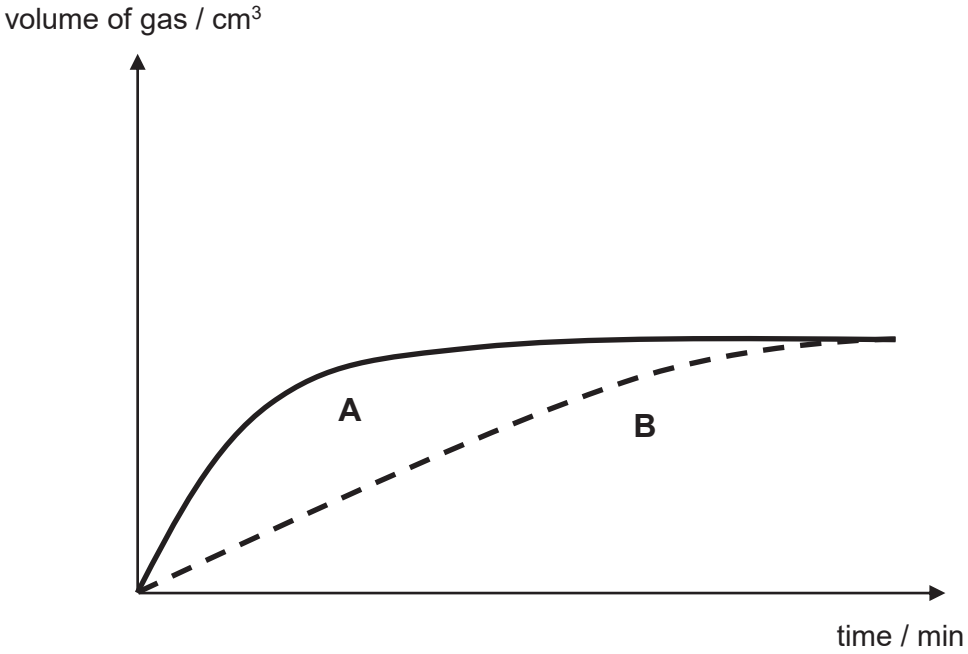
[2]

(ii) Describe a test to confirm the identity of the gas produced.

...……..……

...……[1]

(c) The graph below shows the results obtained with test tube **A** and test tube **B**.



(i) Explain why the volume of gas produced is the same for test tubes **A** and **B**.

.....

.....

.....[2]

(ii) Using collision theory, explain the difference in results for test tubes **A** and **B**.

.....

.....

.....

.....

.....[2]

(d) In the graph in **(c)**, sketch the results obtained with test tube **C**. Label the graph **C.** [1]

(e) An experiment was conducted with 3.00 cm^3 of 1.00 mol dm^{-3} warm dilute nitric acid and an excess of powdered sodium carbonate.

In the graph in **(c)**, sketch the results obtained in this experiment. Label the graph **W**. [1]

[Total: 10]

End of Paper

The Periodic Table of Elements

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

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

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