SINGAPORE CHINESE GIRLS' SCHOOL
Preliminary Examination
Secondary Four

CANDIDATE NAME	
CLASS	4
CENTRE NUMBER	
REGISTER NUMBER	
INDEX NUMBER	

CHEMISTRY

6092/02

Paper 2 Theory

12 August 2020

1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your class, register number and name 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.

For Examiner's Use	
Section A	/50
Section B	/30
Total	/80

Section A

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

A1 Choose from the following reactions/processes to fill in the blanks. Each reaction/process may be used once, more than once or not at all.

Precipitation	Displacement	Reduction	Decomposition
Neutralisation	Combustion	Oxidation	Ionisation

a) When rubidium hydroxide reacts with carbonic acid……. occurs.

b) Rusting occurs when iron undergoes ……..…..

c) Hydrogen peroxide undergoes …… to produce water and oxygen.

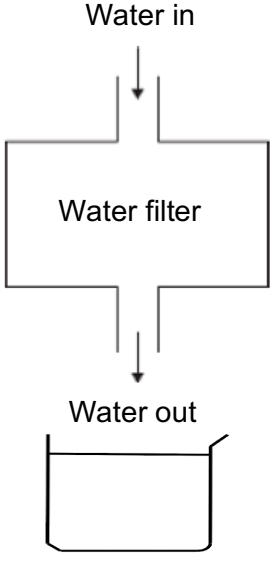
d) …….. occurs when hydrogen chloride gas dissolves in water.

e) Zinc can be obtained from zinc oxide by ……

[Total: 5]

A2 One of the processes in purification of water is filtration.

a) The diagram shows a water filter used in the home. A student collected a sample of water from the filter.



Describe how the student could show that the filtered water contains dissolved salts without using a chemical test. [1]

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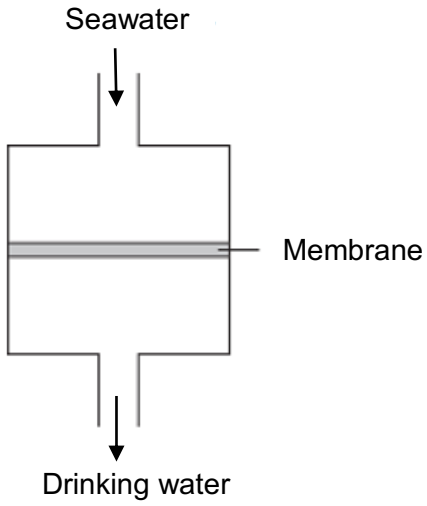
b) Seawater is purified to make drinking water by forcing it through a membrane.



Suggest why water molecules can pass through the membrane, but sodium ions and chloride ions cannot. [1]

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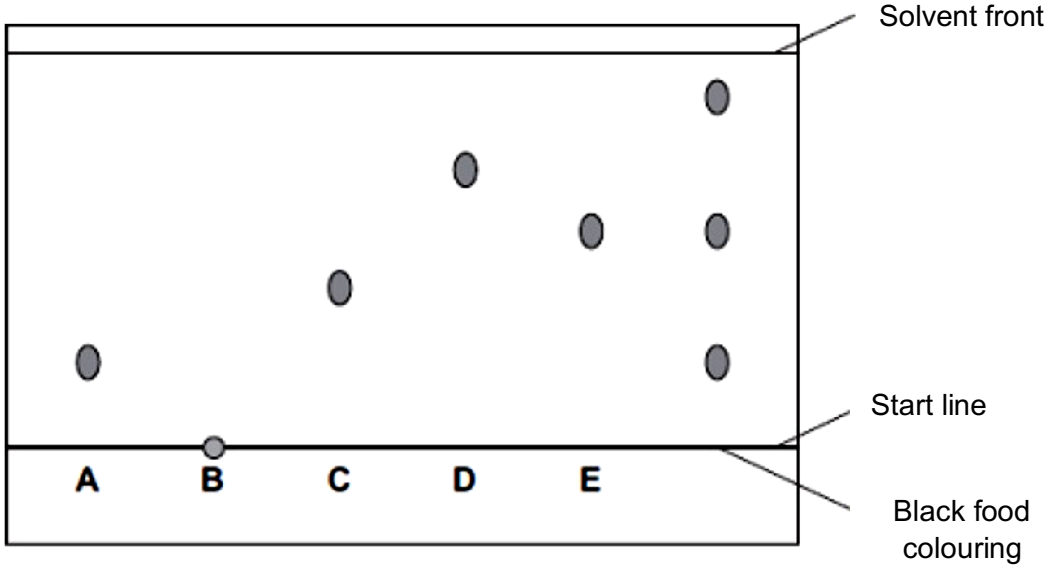
c) Chromatography can be used to separate components of a mixture.

A student used paper chromatography to analyse a black food colouring. The student placed spots of known food colours, **A**, **B**, **C**, **D** and **E**, and the black food colouring on a sheet of chromatography paper and carried out paper chromatography using ethanol as the solvent.

The results are shown on the chromatogram below.



i) Which of the known food colours is the least soluble in ethanol? …… [1]

ii) What does the chromatogram tell you about the composition of the black food colouring? [2]

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The table below gives the results of chromatography experiments that were carried out on some known food colours, using ethanol as the solvent.

Name of food colour	**Distance from start line to solvent front in mm**	**Distance moved by food colour in mm**	**R_f value**
Ponceau 4R	62	59	0.95
Carmoisine	74	45	0.61
Fast red	67	27	0.40
Erythrosine	58	17	0.29

iii) Using the results of the chromatogram and the information in the table, suggest which of the food colours in the table could be food colour **C**? Explain your answer, showing clearly the necessary calculations. [2]

[Total: 7]

A3 Hydrogen fluoride, HF, has a simple molecular structure. It is soluble in water.

a) Suggest two other physical properties of hydrogen fluoride. [2]

1 ……

2 ……...

b) Hydrogen fluoride dissolves in water to form dilute hydrofluoric acid, a ***weak acid***.

i) With the help of an equation, explain why hydrofluoric acid is a ***weak acid***. [2]

.....

……..

ii) Dilute hydrofluoric acid reacts with excess magnesium. The salt formed is magnesium fluoride.

Calculate the volume of gas produced if the acid solution contains 0.200 g of hydrofluoric acid. [2]

iii) Explain, in terms of structure and bonding, why magnesium fluoride has a high melting point. [2]

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…….

iv) Draw a dot and cross diagram to show the bonding in magnesium fluoride. [2]

[Total: 10]

A4 Sodium peroxodisulfate reacts with potassium iodide solution. The ionic equation for this reaction is as shown.

$$S_2O_8^{2-}(aq) + 2I^-(aq) \longrightarrow 2SO_4^{2-}(aq) + I_2(aq)$$

The table shows how the relative rate of this reaction changes when different concentrations of peroxodisulfate ions and iodide ions are used.

Experiment	Concentration of $S_2O_8^{2-}$ in mol/dm^3	Concentration of I^- in mol/dm^3	Relative rate of reaction
1	0.008	0.02	1.7
2	0.016	0.02	3.3
3	0.032	0.02	6.8
4	0.008	0.04	3.4
5	0.008	0.08	6.9

a) Describe an observation for the reaction. [1]

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b) Describe, using the information in the table, how increasing the concentration of peroxodisulfate ions affects the relative rate of reaction. [1]

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c) Explain, in terms of oxidation states, why this is a redox reaction. [2]

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d) Iron(III) ions, Fe^{3+}, catalyse this reaction. Explain how catalysts increase the rate of a reaction. [1]

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e) Describe a chemical test you would carry out to determine if the iron(III) ions were still present at the end of the reaction. State what you would expect to observe. [2]

Test .....

Observation.....

(f) Peroxodisulfate ions also react with iron(II) ions. The products are iron(III) ions and sulfate ions. Construct the ionic equation for this reaction. [1]

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[Total: 8]

A5 A 1.50 g sample of solid lead(II) nitrate is added to 125 cm^3 of 0.100 mol/dm^3 sodium iodide solution.

a) Write the equation for the reaction. [1]

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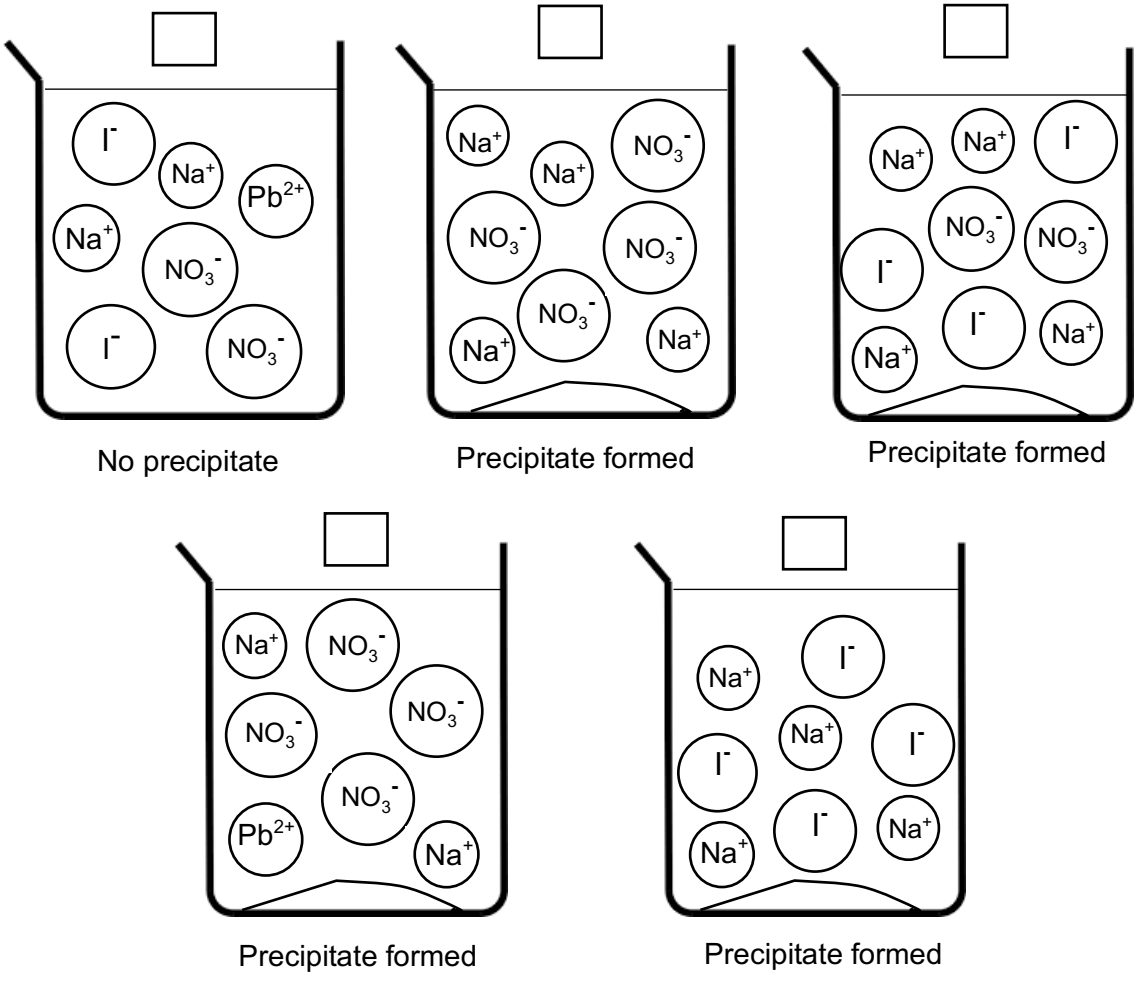
b) Identify the limiting reactant in the reaction, showing your calculations clearly. [2]

c) Using your answer in **(b)**, calculate the concentration of the nitrate ions in the mixture after the reaction is complete. [2]

d) Place a √ in the box to indicate the diagram that best represents the mixture when the reaction is complete. The diagrams do not show the actual number and ratio of ions present. [1]



e) Describe how a pure, dry sample of lead(II) nitrate crystals can be prepared from insoluble lead(II) oxide. [3]

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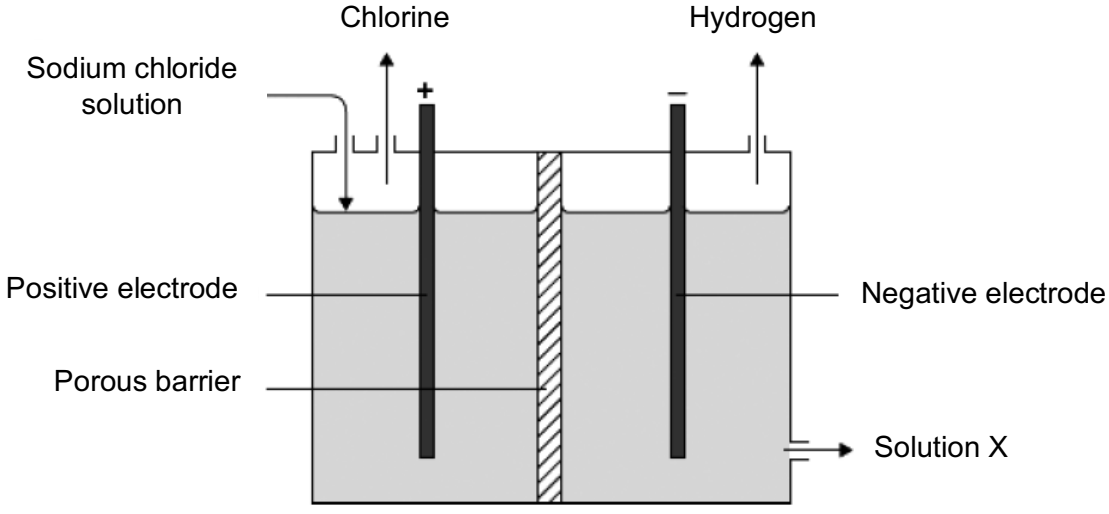
[Total: 9]

A6 The electrolysis of concentrated sodium chloride solution is an industrial process which produces three products; chlorine, hydrogen and solution X.



a) Graphite electrodes are used in the electrolysis. Explain, in terms of structure and bonding, why graphite conducts electricity. [2]

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b) Solution X is alkaline. Name solution X and explain how it is produced in the electrolysis. [3]

Solution X is ……

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[Total: 5]

A7 A group of students were given three different colourless solutions in separate beakers.

They knew that the solutions were potassium iodide, calcium nitrate and ammonium sulfate.

But they did not know which solution was in each beaker. They decided to test each solution with acidified silver nitrate and acidified barium chloride.

	Potassium iodide	**Calcium nitrate**	**Ammonium sulfate**
Test with acidified silver nitrate		No change observed	No change observed
Test with acidified barium chloride			

a) Complete the table to give the expected observations for each solution. [3]

b) Their teacher suggested that the students could also identify the solutions using aqueous sodium hydroxide.

Do you agree? …….

Explain your answer by tabulating the expected observations in a table similar to the one above.

[3]

[Total: 6]

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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.

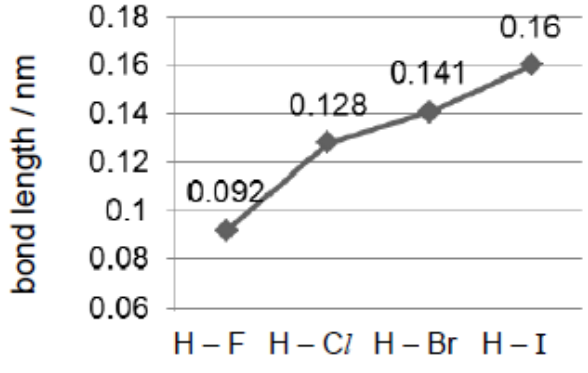
B8 Read the information about hydrogen halides and their chemical properties.

Hydrogen halides are formed when halogens react with hydrogen. The observations for these reactions are shown below.

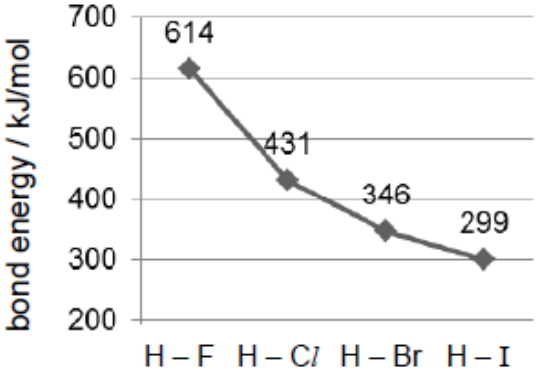
Reaction	Observation
$H_2 + F_2 \rightarrow 2HF$	Reacts explosively even in the dark at -200°C
$H_2 + Cl_2 \rightarrow 2HCl$	Reacts explosively in sunlight but takes place slowly in the dark
$H_2 + Br_2 \rightarrow 2HBr$	
$H_2 + I_2 \rightleftharpoons 2HI$	Reacts very slowly in sunlight even on heating with platinum

Stability of hydrogen halides is affected by bond length and bond energy of the halides.

Graphs 1 and 2 show how bond length and bond energy vary for the different halides.



Graph 1



Graph 2

Bond length refers to the average distance between the nuclei of two bonded atoms in a molecule.

Bond energy is a measure of the bond strength in a chemical bond. It is the energy required to break one mole of molecules into their individual atoms.

When heated, the hydrogen halides decompose into its constituent elements.

Hydrogen halide	HF	HCl	HBr	HI
Thermal decomposition at 1000°C	none	negligible	0.5 %	33 %

Hydrogen halides are extremely soluble in water, forming acidic solutions.

a) Predict the observation for the reaction of bromine with hydrogen gas. [1]

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b) Suggest why platinum is added when iodine is reacted with hydrogen gas. [1]

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c) Describe the relationship between the bond length and bond energy of the hydrogen halides. Hence explain why the reaction of iodine with hydrogen is a reversible reaction unlike the other reactions. [2]

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d) Describe what would be observed when a hot glass rod is plunged into separate gas jars containing HCl and HI. [2]

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ei) Given that the bond energy of the Br – Br bond is 193 kJ/mol and the bond energy of the H – H bond is 432 kJ/mol, calculate the enthalpy change for the formation of hydrogen bromide from hydrogen and bromine. [2]

ii) Explain, in terms of bond breaking and bond making, whether this reaction is exothermic or endothermic. [2]

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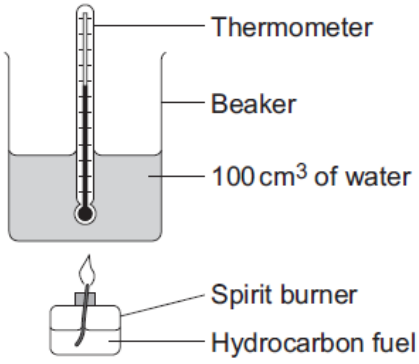
iii) Draw a labelled energy profile diagram for this reaction, showing clearly the activation energy and enthalpy change of the reaction. [2]

[Total: 12]

B9 A group of students investigated the energy released by the combustion of four hydrocarbon fuels using the apparatus shown.



Each hydrocarbon fuel was burned for two minutes. The table shows the students' results.

	After two minutes				
Name and formula of hydrocarbon fuel	**Mass of fuel used in g**	**Temperature increase of water in °C**	**Energy released by fuel in kJ**	**Energy released by 1.0 g of fuel in kJ**	**Relative amount of smoke in the flame**
Hexane, C_6H_{14}	0.81	40	16.80	20.74	very little smoke
Octane, C_8H_{18}	1.10	54	22.68	20.62	some smoke
Decane, $C_{10}H_{22}$	1.20	58	24.36		smoky
Dodecane, $C_{12}H_{26}$	1.41	67	28.14	19.96	very smoky

a) Calculate the energy released by 1.0 g of decane in kJ. [1]

b) Suggest one key source of error present in this experiment and describe how this error affects the results. [1]

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c) The students noticed that the bottom of the beaker became covered in a black substance when burning these fuels.

i) Explain the presence of the black substance. [1]

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ii) Suggest why hexane, C_6H_{14}, produced less black substance when burned compared to hexene, a compound with formula C_6H_{12}. [1]

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d) A student concluded that hexane is the best of the four fuels.
Give two reasons why the results in the table support this conclusion. [2]

1……..

2……..

e) Most car engines use liquid petrol as a fuel. Car engines could be developed to use hydrogen as a fuel. Describe one advantage and one disadvantage of using hydrogen instead of petrol as a fuel.

[2]

Advantage: ……

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Disadvantage: ……..

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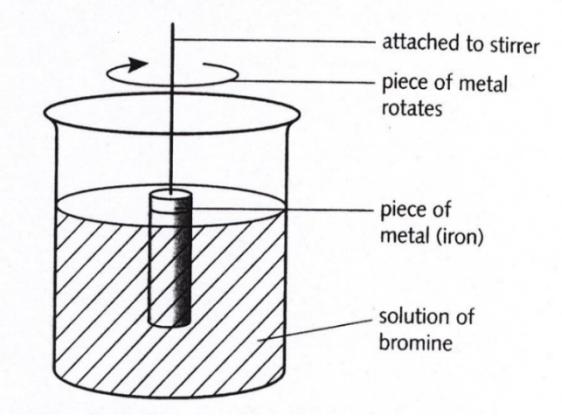
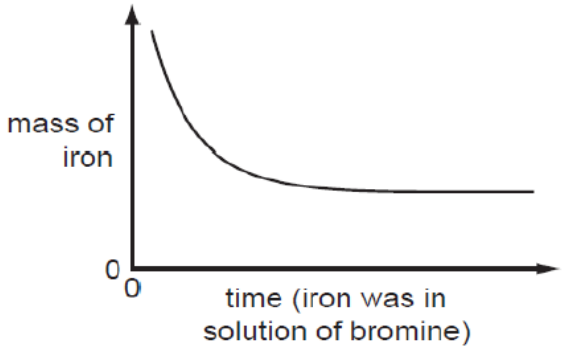
[Total: 8]

EITHER

B10 The rate of reaction between a metal and bromine can be studied using the apparatus shown below.



A cylindrical piece of iron, was weighed and placed in the solution as shown above. The iron was removed at regular intervals and the stopwatch was paused. The piece of iron was washed, dried, weighed and then placed in the solution again. The stopwatch was restarted and the reaction continued. The mass of iron was plotted against time. The graph shows the results obtained.



a) Explain the shape of the graph. [3]

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b) From the results (mass of metal and time), the rate of the reaction can be calculated.

How would the rate of the reaction change if the cylindrical piece of iron was hammered to form a flat sheet of iron and placed in the bromine solution? Explain your answer. [2]

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c) The experiment was conducted using two solutions of bromine of equal volume but different concentration. A piece of iron with equal mass was placed in each solution. The mass of the iron was measured at one minute intervals. The table shows the loss in mass of the iron after one minute.

Experiment	**Concentration of bromine solution**	**Loss in mass of iron after one minute**
1	0.05 mol/dm^3	10 mg
2	0.1 mol/dm^3	20 mg

Explain, in terms of collisions between particles, the difference in the results obtained. [2]

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d) Iron also reacts with iodine solution. Predict the loss in mass of iron after one minute if 0.05 mol/dm^3 of iodine solution of equal volume was used instead of bromine solution. Suggest a reason for your answer. [1]

Loss in mass of iron = ……

……

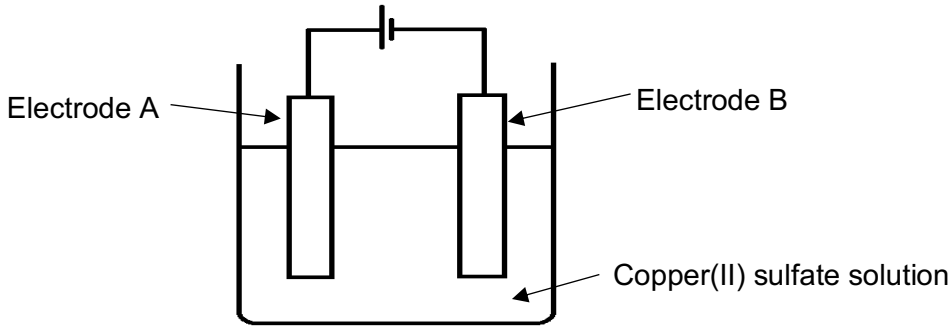
……

e) When solid iron is heated in bromine gas, iron(III) bromide is formed. Calculate the minimum mass of iron required to react with 1200 cm^3 of bromine gas. [2]

[Total: 10]

OR

B10 A student investigated the electrolysis of copper(II) sulfate solution using copper electrodes. The student's method is shown below.



Step 1 Weigh two clean strips of copper.

Step 2 Use one strip as electrode A and the other as electrode B.

Step 3 Carry out electrolysis.

Step 4 After electrolysis, wash both copper strips with ethanol (a liquid that boils at 78°C).

Step 5 Dry the strips of copper and re-weigh them.

a) Suggest why the copper strips would dry more quickly when washed with ethanol rather than with water. [1]

……..

b) Give the ionic half-equation, with state symbols, for the reaction at electrode A. [2]

……

c) The student's results are shown in the table.

	Electrode A	Electrode B
Mass before electrolysis/g	8.78	7.95
Mass after electrolysis/g	**x**	8.25

i) Electrode B increases in mass. Explain why this happens. [1]

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ii) Predict the theoretical value of **x** in the table. …….. [1]

iii) The actual value of **x** obtained in the experiment was less than the theoretical value. Assuming that the experiment was carried out correctly, suggest a reason for this discrepancy. [1]

……..

……..

d) Given that 1 Faraday is the electrical charge of 1 mole of electrons, calculate the number of Faradays that would cause electrode B to increase by 0.300 g. [2]

e) The student repeated the investigation using graphite electrodes instead. Compare the results obtained from this electrolysis with the results obtained when copper strips were used. Explain the difference in results. [2]

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[Total: 10]

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.).