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Candidate Name:	Class	Index No.

FUHUA SECONDARY SCHOOL

Secondary Four Express

Preliminary Examinations 2019

4E

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CHEMISTRY

6092/01

Paper 1 Multiple Choice

2 September 2019
0755 – 0855
1 hour

READ THESE INSTRUCTIONS FIRST

INSTRUCTIONS TO CANDIDATES

Write in soft pencil.

Write your name and index number on the Answer Sheet in the spaces provided unless this has been done for you.

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 provided.

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 13.

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

PARENT'S SIGNATURE	FOR EXAMINER'S USE
	/40

Setter: Mdm Hia Soo Ching *Vetter: Mr Elton Tan*

This question paper consists of 13 printed pages including this page.

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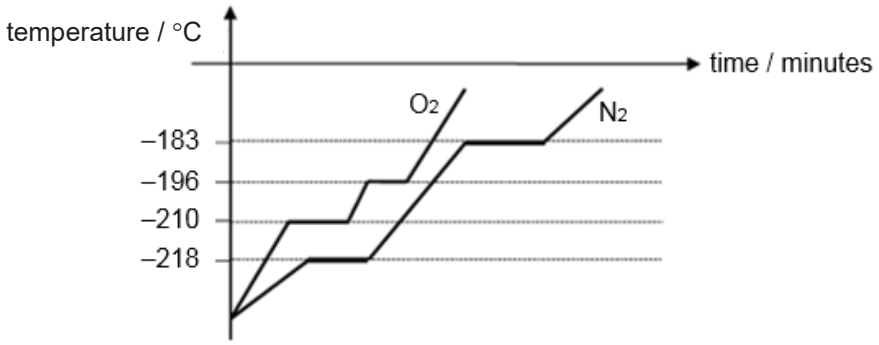
Multiple Choice Questions [40 marks]

Answer **all** questions and shade your answers on the OMR sheet provided.

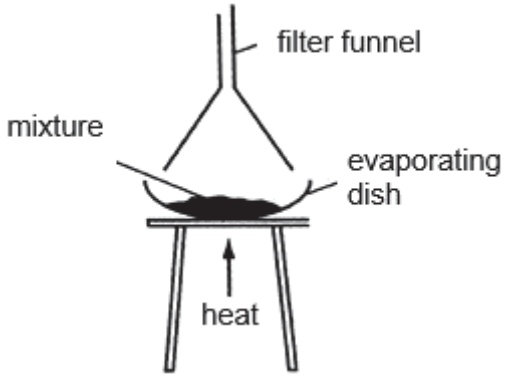
1 The graphs (not drawn to scale) show the heating curves of oxygen and nitrogen over a period of time.



Which of the following statements about a mixture of oxygen and nitrogen is correct?

A At -190°C, both oxygen and nitrogen exist as a liquid.
B At -200°C, both oxygen and nitrogen exist in the same state.
C At -215°C, both nitrogen and oxygen molecules are vibrating about fixed positions.
D At -185°C, both oxygen and nitrogen molecules move rapidly in all directions.

2 Refer to the following setup.



Which of the following mixtures can be separated into its components using this setup?

A ammonium chloride and iodine
B copper(II) sulfate and sodium chloride
C potassium iodide and copper(II) sulfate
D sodium chloride and ammonium chloride

3 Which of the following substances does **not** contain atoms bonded to other atoms by four covalent bonds?

A graphite
B polypropene
C silicon dioxide
D terylene

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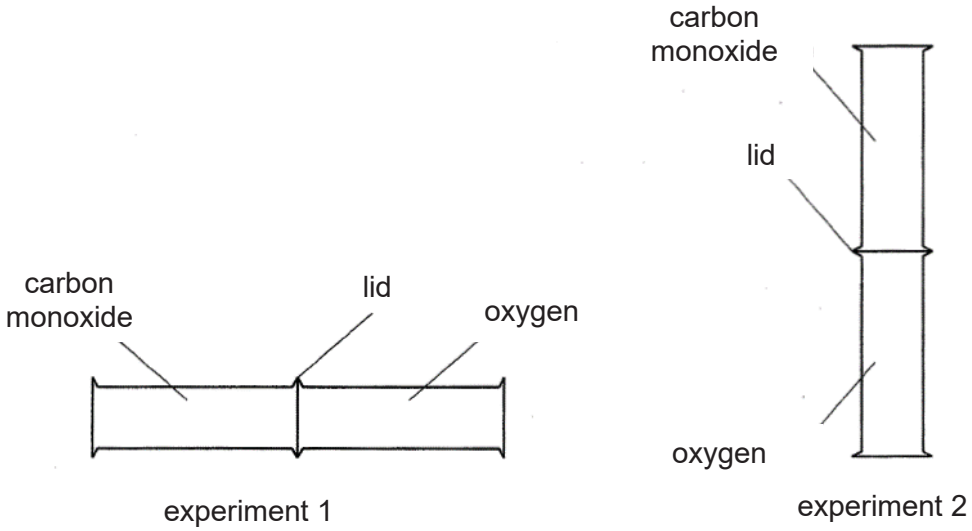
4 The diagram shows the start of experiment 1 and 2 using gas jars of carbon monoxide and oxygen arranged in two different orientations.
All other conditions are kept constant.



The lids are removed and the gases are allowed to mix.
Which of the following observations would you expect for the experiments?

A The rate of oxygen diffusing is much faster than rate of carbon monoxide diffusing in both experiments.
B The rate of carbon monoxide diffusing is much faster in experiment 1 than in experiment 2.
C In experiment 2, the final concentration of carbon monoxide in the top jar will be less than its original concentration.
D The final concentration of carbon monoxide in the left jar in experiment 1 is the same as the final concentration of carbon monoxide in the top jar in experiment 2.

5 A salt, P, on warming with aqueous sodium hydroxide, showed no visible reaction. When aluminium powder was added, a gas that turned damp red litmus paper blue evolved. What is salt P?

A $Ca(NO_3)_2$
B KNO_3
C NH_4Cl
D NH_4NO_3

6 Tritium is an isotope of hydrogen and has the symbol T.
Which formula is **incorrect** for a tritium compound?

A CaOT
B NT_3
C TNO_3
D T_2O

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7 Compound X contains two elements, metal Y and non-metal, Z.

X consists of a lattice of positive and negative ions. Each positive ion is surrounded by eight anions and each negative ion is surrounded by four cations.

What ions are present in, and what is the formula of, compound X?

	ions present	formula
A	Y^{+} Z^{2-}	Y_2Z
B	Y^{2+} Z^{-}	YZ_2
C	Z^{+} Y^{2-}	Z_2Y
D	Z^{2+} Y^{-}	ZY_2

8 Which of the following substances contain delocalised electrons?

1 iron
2 steel
3 diamond
4 graphite

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

9 Aqueous lead(II) nitrate can be distinguished from aqueous zinc nitrate by adding any of the following solution except

A aqueous potassium chloride.
B aqueous sodium sulfate.
C dilute sulfuric acid.
D sodium hydroxide solution.

10 5 g of element X reacted completely with 8 g of element Y to form a compound with the formula XY_2.
Given that the relative atomic mass of Y is 80, what is the relative atomic mass of X?

A $\frac{5}{13} \times 80 \times 2$

B $\frac{5}{13} \times 80 \times \frac{1}{2}$

C $5 \times \frac{8}{80} \times \frac{1}{2}$

D $5 \times \frac{80}{8} \times 2$

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11 In an experiment, 8.0 cm^3 of 1.00 mol/dm^3 aqueous barium chloride was mixed with 8.0 cm^3 of 1.00 mol/dm^3 of aqueous silver nitrate.
Which of the following ions are present in the solution produced?

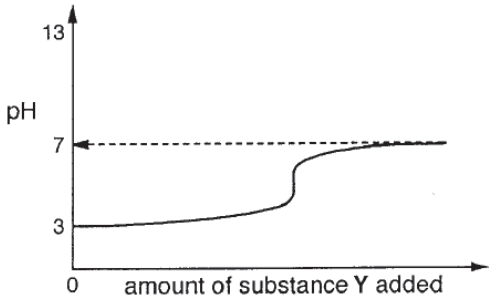
1 Ba^{2+}
2 Cl^-
3 Ag^+
4 NO_3^-

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

12 Solutions P and Q were tested with a few drops of Universal Indicator.
Solution P turned the indicator red while solution Q turned the indicator yellow.
It can be deduced that

A Solution P has a higher pH than solution Q.
B Solution Q is more alkaline than solution P.
C Solution Q reacts with calcium carbonate to give carbon dioxide gas.
D The concentration of hydrogen ions in Q is higher than the concentration of hydrogen ions in solution P.

13 Substance Y was added bit by bit, with stirring, to aqueous solution Z.
The changes in pH of the mixture are shown in the graph.



What could Y and Z be?

	Y	Z
A	aluminium oxide	hydrochloric acid
B	calcium oxide	nitric acid
C	sodium oxide	ethanoic acid
D	zinc oxide	propanoic acid

14 An element burns in air to form a compound which does not react with both acids and alkalis.
Which element could it be?

A aluminium
B carbon
C iron
D phosphorus

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15 Which of the following properties shows that a certain substance, M, is alkaline?

A Solution M dissolves copper(II) oxide.
B On adding dilute hydrochloric acid to solution M, carbon dioxide is given off.
C Solution M when warmed with aqueous ammonium chloride gives off ammonia gas.
D Solution M forms brown precipitate when reacted with iron(III) chloride solution.

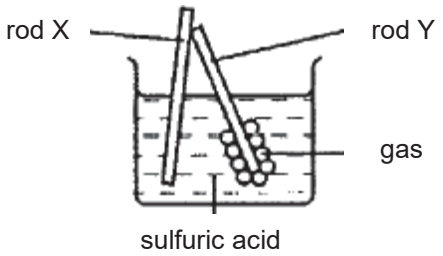
16 In which of the following experiments will a redox reaction occur?

A Adding nitric acid to aqueous ammonia.
B Adding copper turnings to aqueous silver nitrate.
C Adding chlorine water to aqueous potassium fluoride.
D Adding aqueous sodium hydroxide to aqueous copper(II) nitrate.

17 In which of the following does vanadium have the lowest oxidation number?

A V^{3+}
B VO^{2+}
C NH_4VO_3
D V_2O_5

18 In an experiment, two different metal rods, X and Y, were dipped in dilute sulfuric acid, with their top ends touching. A gas was collected around rod Y.



Which of the following can you conclude about this experiment?

A Electrons flow from rod Y to X.
B Rod X is more reactive than rod Y.
C Rod Y reacts with acid to produce hydrogen gas.
D Ions of Y can be found in the solution but not ions of X.

19 Which of the following reactions is **not** involved in the manufacture of iron from the blast furnace?

A Coke burns in air to form carbon dioxide.
B Acidic impurities are removed by calcium oxide.
C Limestone is decomposed to form calcium oxide.
D Haematite is reduced by carbon dioxide to form iron.

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20 W, X, Y and Z are four metals which form cations W^+, X^{2+}, Y^+ and Z^{2+}.
The following are information on some of the reactions that the metals undergo.

$$X^{2+}(aq) + W(s) \rightarrow \text{no reaction}$$
$$Z^{2+}(aq) + 2W(s) \rightarrow 2W^+(aq) + Z(s)$$
$$Y_2CO_3(s) \xrightarrow{\text{heat}} \text{no reaction}$$
$$Z(s) + 2H^+(aq) \rightarrow Z^{2+}(aq) + H_2(g)$$

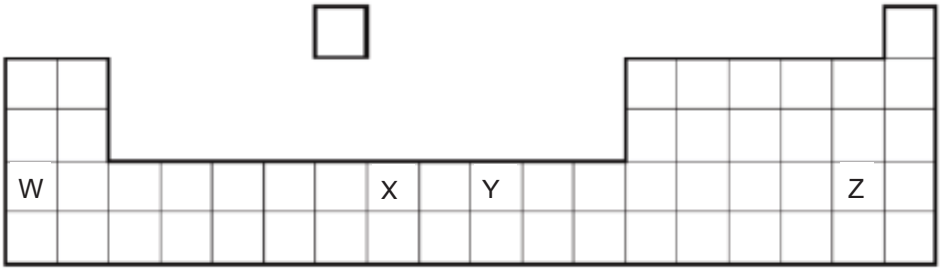
The order of decreasing reactivity of the metals are

A X, W, Z, Y.
B X, Y, Z, W.
C Y, X, W, Z.
D Z, W, X, Y.

21 Which of the following method is most likely used to extract an element with an electronic structure of 2.8.8.2?

A electrolysis of its aqueous chloride
B electrolysis of its molten ore
C reduction with carbon
D reduction with hydrogen

22 Part of the Periodic Table is shown below.



1 Elements W, X and Y have high melting points.
2 Y is less reactive than W.
3 Z can form both ionic and covalent compounds.
4 X and Y form compounds that are coloured.

Which of the following statements are correct?

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

23 Which statement is most likely to be true for astatine, which is in Group VII of the Periodic Table?

A Astatine is a stronger oxidising agent than chlorine.
B Astatine reacts with hydrogen to form a compound with formula HAt_2.
C Aqueous potassium astatide reacts with aqueous silver nitrate to form aqueous silver astatide.
D Sodium astatide is less stable than sodium chloride.

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24 Which of the following reactions is endothermic?

A $2H \rightarrow H_2$
B $H_2O(l) \rightarrow H_2O(g)$
C $2H_2 + O_2 \rightarrow 2H_2O$
D $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

25 What are the effects of temperature of reactants and use of a catalyst on the activation energy and enthalpy change of a reaction?

	effect of temperature		effect of catalyst	
	activation energy	enthalpy change	activation energy	enthalpy change
A	decreases	no change	decreases	no change
B	decreases	decreases	no change	no change
C	no change	no change	decreases	no change
D	no change	no change	no change	no change

26 In the reaction between calcium carbonate and ethanoic acid, the following changes could be made to the conditions.

1 Increase the concentration of ethanoic acid
2 Increase the particle size of calcium carbonate.
3 Increase the temperature of the system.
4 Increase the pressure of the system.

What changes would increase the rate of reaction?

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

27 Refer to the following bond energy table.

bond	bond energy / kJ mol^{-1}
F - F	158
H - H	436
H - F	556

It can be deduced that

A the bonds in fluorine is the strongest.
B fluorine gas is more reactive than hydrogen gas.
C hydrogen fluoride molecules are the least stable.
D the energy produced when forming 1 mole of hydrogen fluoride molecules from its elements is 518 kJ.

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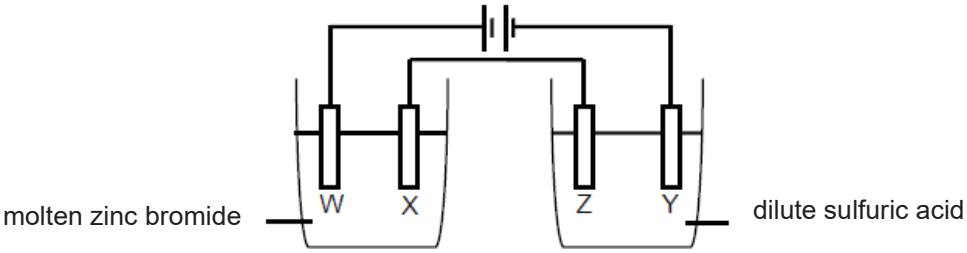
28 Which statement is true for both simple and electrolytic cells.

	simple cell	electrolytic cell
A	It converts electrical energy into chemical energy.	It converts chemical energy into electrical energy.
B	Oxidation occurs at negative electrode.	Oxidation occurs at positive electrode
C	Electrons flow from the cathode to the anode.	Electrons flow from the cathode to the anode.
D	Mass of the anode will decrease.	Mass of the anode may increase.

29 Refer to the following electrolytic setup. All electrodes used are graphite.



What could be observed after a few minutes?

A A silvery solid is formed at electrode W.
B A red brown liquid is formed at electrode X.
C A pale yellow gas is formed at electrode Y.
D A colourless and odourless gas is formed at electrode Z.

30 In electroplating a silver spoon with copper, which combination of anode, cathode and electrolyte is the most suitable?

	anode	cathode	electrolyte
A	copper	silver spoon	copper(II) nitrate solution
B	copper	silver spoon	silver nitrate solution
C	silver spoon	copper	copper(II) nitrate solution
D	silver spoon	copper	silver nitrate solution

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

substance	percentage composition by mass	electrical conductivity when solid	effect of heat
P	constant	yes	solid burns in air to form an oxide.
Q	varies	no	liquid burns to form carbon dioxide and water.
R	constant	no	solid decomposes to form two products.
S	varies	yes	solid melts

Which classification of the substances as an element, a mixture or a compound is correct?

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

32 Ammonium nitrate, NH_4NO_3, ammonium sulfate, $(NH_4)_2SO_4$, urea, $(NH_2)_2CO$ and ammonium phosphate, $(NH_4)_3PO_4$ are all fertilisers that can be produced from ammonia.

Which of these contains the most nitrogen per kilogram of fertiliser?

A ammonium nitrate
B ammonium sulfate
C ammonium phosphate
D urea

33 The Haber process is a reversible reaction as some of the ammonia formed is unstable as it decomposes readily back into its reactants.
Which of the following method is used to prevent this from happening?

A Adding water to dissolve ammonia.
B Cooling the mixture to liquefy ammonia.
C Filter the mixture to remove ammonia.
D Fractional distil the mixture to separate ammonia gas.

34 What is the volume of air required for a mixture of 20 cm^3 of methane and 40 cm^3 of carbon monoxide to burn completely?

A 60 cm^3
B 80 cm^3
C 300 cm^3
D 400 cm^3

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35 Which of the following reagents could be used to distinguish between samples of ethanol and ethanoic acid?

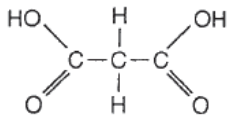
1 aqueous bromine
2 sodium carbonate
3 aqueous sodium chloride
4 litmus solution

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

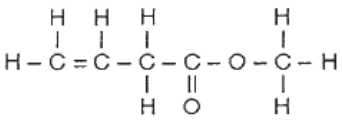
36 How does the number of carbon, hydrogen and oxygen atoms in an ester differ from the total number of carbon, hydrogen and oxygen atoms in the alcohol and carboxylic acid from which the ester was derived?

	carbon atoms	hydrogen atoms	oxygen atoms
A	same	same	same
B	less	same	less
C	same	less	less
D	less	less	less

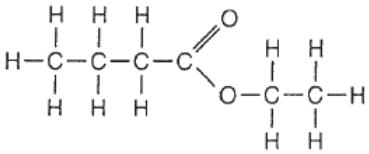
37 Which of the following tests can be used to distinguish the following organic compounds, I, II and III separately from each other.



I



II



III

test	1	Adding aqueous bromine.
	2	Adding powdered magnesium.
	3	Warming with acidified potassium manganate(VII).

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

38 The chemical equation for a reaction is shown below.

$$CH_3COOH + Br_2 \leftrightharpoons CH_2BrCOOH + HBr$$

This reaction is an example of a/an

A addition reaction.
B condensation reaction.
C esterification reaction.
D substitution reaction.

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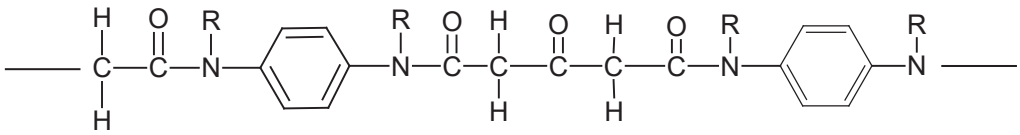
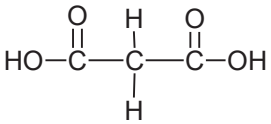
39 A section of a polymer is shown below.

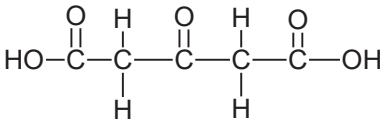


Which of the following shows a monomer involved in the formation of the above polymer?

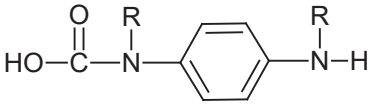
A



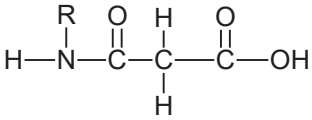
B



C



D



40 Three metal oxides each have the formula G_2O_3.
Which statements about these oxides are correct?

1 If the relative molecular mass for the oxide is 152, metal G is a transition element.

2 If the relative molecular mass for the oxide is 160, the oxide of metal G can react with both acid and alkali.

3 If the relative molecular mass for the oxide is 102, the oxide of G is formed when metal G reacts with steam.

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

End of Paper

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The Periodic Table of Elements

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

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 –		

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.).

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Candidate Name:	Class	Index No.

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Secondary Four Express

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CHEMISTRY 6092/02

Paper 2

28 August 2019
1115 – 1300
1 hour 45 minutes

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number in the spaces provided on top of this page.

Write in dark blue or black pen.

You may use a HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

Section A (50 marks)
Answer **all** questions.
Write your answers in the spaces provided.

Section B (30 marks)
Answer all **three** questions, the last question is in the form of either/or.
Write your answers in the spaces provided.

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

A copy of the Periodic Table is printed on page 22.

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

PARENT'S SIGNATURE

FOR EXAMINER'S USE		
Section A	Section B	**Total**
/50	**/30**	**/80**

Setter: *Mdm Hia Soo Ching* Vetter: *Mr Elton Tan*

This question paper consists of 22 printed pages including this page.

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Section A [50 marks]

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

A1 Table A1.1 shows sub-atomic particles found in particles, L to S. The letters are not the symbols of the elements.

particle	electrons	protons	neutrons
L	6	6	6
M	10	8	8
N	8	8	10
O	12	12	12
P	10	12	12
Q	13	13	13
R	1	1	1
S	13	13	14

Table A1.1

Use the letter(s) to answer the following questions.

(a) Which particle is an atom of oxygen?

_____ [1]

(b) Which particle will combine with oxygen atoms to form a compound that does **not** react with alkali and acid?

_____ [1]

(c) Which pair of particles are isotopes?

_____ [1]

(d) **(i)** Which pair of particles are found in a compound that can conduct electricity in aqueous and molten states?

_____ [1]

(ii) Draw a ‘dot-and-cross’ diagram for the compound in **(d)(i)**.
Show outer electrons only.

[2]

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(e) Which particle is an atom of an element that can have oxidation states +1, 0 and -1? Explain your answer.

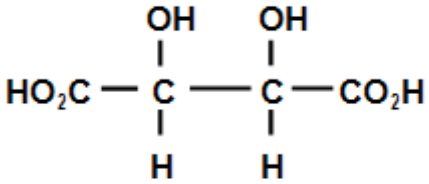
_____

_____ [2]

[Total: 8]

A2 Both phosphoric acid and tartaric acid are weak acids. The formulae of both acids are given as follows:

H_3PO_4



phosphoric acid

tartaric acid

(a) Describe a simple test that can be used to show that tartaric acid or phosphoric acid is a weak acid.

_____

_____ [1]

(b) Describe a chemical test to distinguish phosphoric acid from tartaric acid respectively.

_____

_____

_____ [2]

(c) A solution of 0.200 mol/dm^3 potassium hydroxide was titrated against phosphoric acid and tartaric acid separately.
Deduce the ratio of the volume of potassium hydroxide used in titrating fixed volumes and concentrations of phosphoric acid and tartaric acid respectively.

_____ [1]

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(d) Tartaric acid and its salts have many applications. One such salt is copper(II) tartarate which is insoluble in water.
Describe how you will prepare a pure and dry sample of this salt in the laboratory,

_____

_____

_____

_____ [2]

(e) A 2.0 cm length of magnesium ribbon was added to 100 cm^3 of 2.00 mol/dm^3 phosphoric acid. All the magnesium reacted and the temperature of the acid increased by 6.0°C.

(i) Predict the temperature change when 1.0 cm length of magnesium ribbon was reacted with 100 cm^3 of 2.00 mol/dm^3 phosphoric acid.

_____ [1]

(ii) Predict the temperature change when 2.0 cm length of magnesium ribbon was reacted with 100 cm^3 of 2.00 mol/dm^3 tartaric acid. Again, all the magnesium reacted. Explain your answer.

_____

_____

_____

_____ [3]

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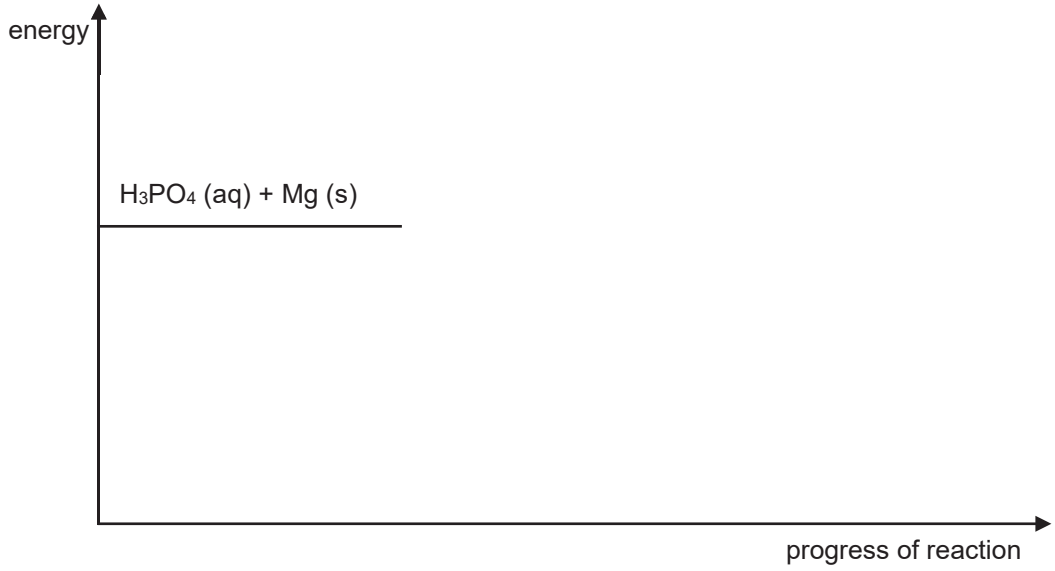
(iii) Complete the energy profile diagram for the reaction between magnesium ribbon and phosphoric acid.

Your diagram should include:

- the formulae of the products,
- the activation energy and
- a label for the enthalpy change of reaction.



[2]

[Total: 12]

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A3 **(a)** Table A3.1 shows information about some organic compounds.
Complete the table by filling in the missing name, formulae and by completing the description of the processes.

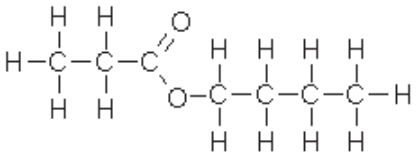
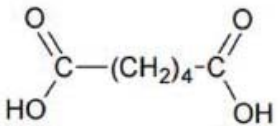
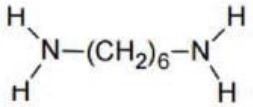
name of compound	structural formula	process(es) used to produce the compound
		Warming of _____ and _____ with concentrated sulfuric acid.
propane		Catalytic _____ _____ to propene.
polybutene		_____ of butene
nylon-6,6		_____ of monomers  and  .

Table A3.1

[4]

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(b) Alkyl halides are a homologous series of organic compounds. They are formed when one halogen atom (X = C*l*, Br, I) bonds with carbon atoms.

Table A3.2 shows the condensed formulae and boiling points of some alkyl halides.

condensed formula	**boiling point / °C**		
	X		
	C*l*	**Br**	**I**
CH_3X	-24.2	3.6	42.4
CH_3CH_2X	12.3	38.4	72.3
$CH_3CH_2CH_2X$	46.6	71.0	102.5
$CH_3CH_2CH_2CH_2X$	78.4	101.6	130.5

Table A3.2

(i) Besides having the same functional group, use the information in the table to give **two** other pieces of evidence that suggest that alkyl halides are a homologous series.

_____

_____

_____ [2]

(ii) Describe and explain the trend in boiling points of alky halides when the halogen atom changes from C*l* to I.

_____

_____

_____

_____

_____ [3]

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(iii) Alkyl halides can be prepared by the reaction of halogen acids with alcohols. For example, hydrochloric acid reacts with methanol to produce methyl chloride and water.

Write an equation for the preparation **ethyl iodide**, showing the displayed formulae of all organic compounds.

[2]

[Total: 11]

A4 Three reactions take place in the catalytic converter installed in car exhaust systems.

1. Conversion of nitrogen oxides (NO, NO_2) into nitrogen.
2. Conversion of carbon monoxide into carbon dioxide.
3. Conversion of hydrocarbons into carbon dioxide and water.

The air/fuel ratio in the car engine affects the conversion efficiency of the catalytic converter. A 'lean' air/fuel mixture to the engine has a higher ratio of air to fuel while a 'rich' air/fuel mixture has a lower ratio of air to fuel.

Figure A4.1 gives the conversion efficiency of a converter based on air/fuel ratio.

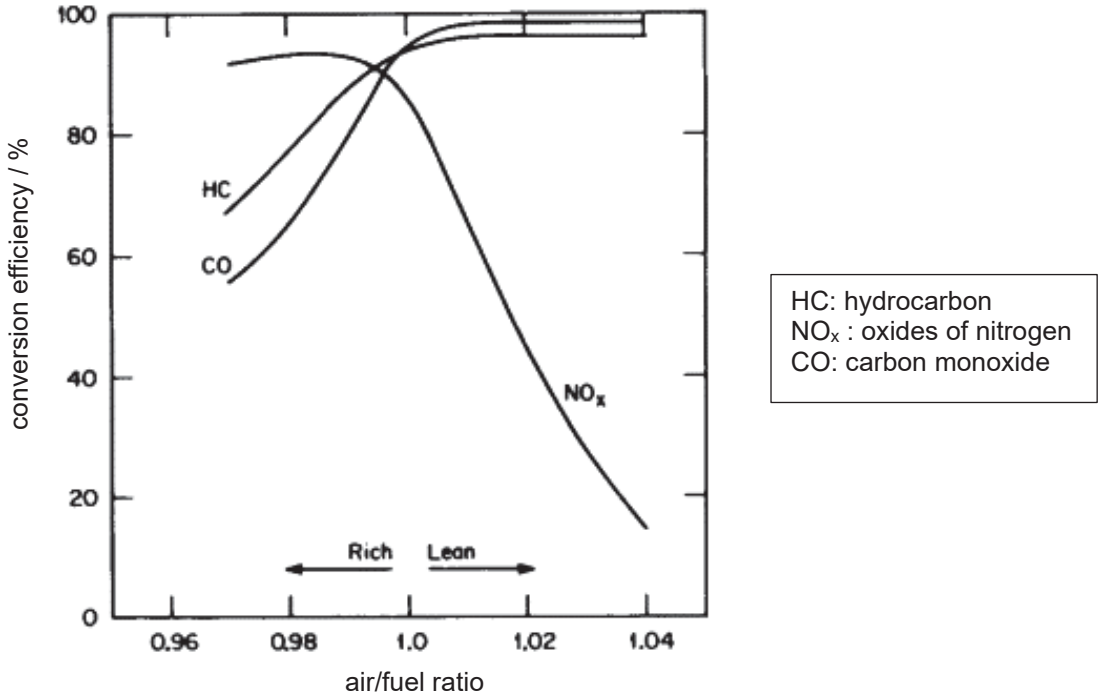

Figure A4.1

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(a) Use oxidation states to explain whether reaction 1 and 2 involves oxidation and reduction.

_____

_____

_____

_____ [2]

(b) Describe and explain how does changing the air/fuel ratio from ‘rich’ to ‘lean’ affect the conversion efficiency of carbon monoxide, nitrogen monoxide and hydrocarbons in the catalytic converter.

_____

_____

_____

_____

_____

_____ [4]

(c) The exhaust gas from vehicles without catalytic converters cause more harm to human health than those from vehicles fitted with catalytic converters.
Explain why this is true.

_____

_____

_____

_____ [2]

[Total: 8]

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A5 Figure A5.1 shows the structures of four solids, A to D.

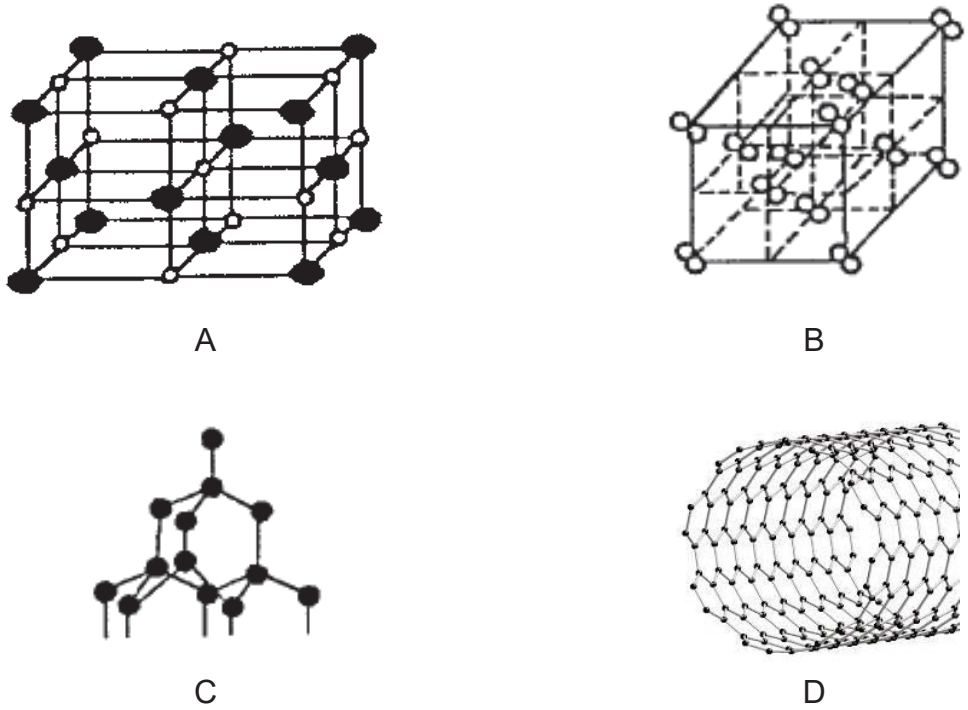

Figure A5.1

Solid C and D are both allotropes of carbon.

(a) State one similarity and one difference in the structure and bonding of solids B and C.

_____

_____

_____

_____ [2]

(b) Compare the electrical conductivity of solids C and D.
Explain in terms of bonding and structure.

_____

_____

_____

_____ [2]

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(c) Both copper(II) oxide and potassium chloride have similar structure as solid A. Explain why the melting point of copper(II) oxide is much higher than that of potassium chloride.

[2]

[Total: 6]

A6 Some samples of carbonates are heated strongly until there is no further change in mass. Table A6.1 shows the mass of solid remaining at the end of the heating.

carbonate	mass before heating / g	mass after heating / g
copper(II) carbonate	2.00	1.29
magnesium carbonate	2.00	0.95
sodium carbonate	2.00	?
zinc carbonate	2.00	1.30

Table A6.1

(a) Although each carbonate is fixed at 2.00 g, the mass of solid remaining is different. Explain why.

[2]

(b) State the mass of solid remaining when sodium carbonate is heated strongly.

[1]

(c) Pure metal can be extracted by further heating the mass of the solid remaining at the end of the reaction in Table A6.1 with dry hydrogen.
State the metal(s) that can be extracted. Write the chemical equation for one such reaction.

[2]

[Total: 5]

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Section B: Free Response Questions [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 The Electrochemical Series

When electrodes of metallic and non-metallic elements in contact with their ions are arranged on the basis of the values of their **standard reduction potentials**, E°, the resulting series is called the **electrochemical series** of the elements.

The **standard reduction potential** of an element is the measure of the tendency of the element to get reduced by gaining electrons. All reduction potentials are measured against the standard hydrogen electrode which is the reference electrode.

The standard potential of any metal or non-metal is measured when in contact with aqueous solutions of their ions at a concentration of 1 mol/dm^3 and temperature of 25 °C. Any gases involved are maintained at a pressure of 1 atmosphere.

Figure B7.1 shows the setup to measure the standard reduction potential of copper. The Cu/Cu^{2+} half-cell is connected to the hydrogen half-cell.

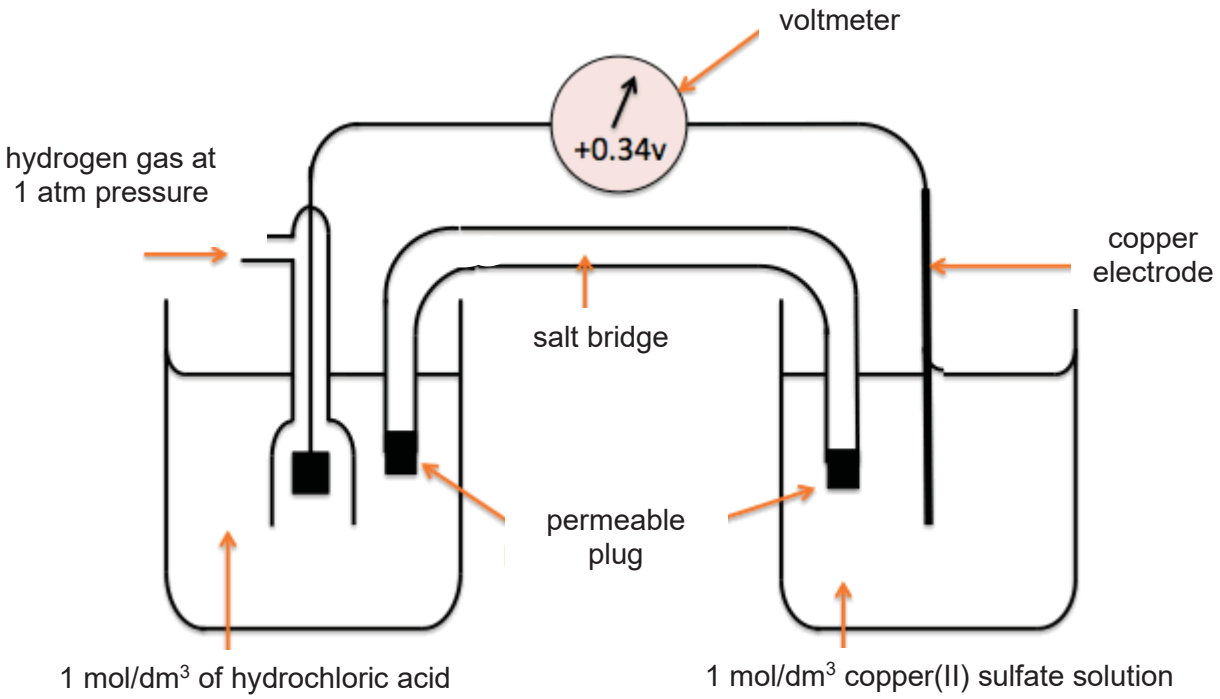

Figure B7.1

[*Source:* https://derekcarrsavvy-chemist.blogspot.com/]

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By international convention, the standard potentials of electrodes are tabulated for reduction half reactions. Electrodes with positive E° values indicate the tendencies of the electrodes to gain electrons more readily and behave as cathodes.

Table B7.2 gives the standard reduction potential, E° of some elements.

element	electrode reaction	standard reduction potential, E° / V
Li	$Li^+ + e^- \rightarrow Li$	-3.05
K	$K^+ + e^- \rightarrow K$	-2.93
Na	…	-2.71
Zn	…	-0.76
Cr	$Cr^{3+} + 3e^- \rightarrow Cr$	-0.74
Fe	$Fe^{2+} + 2e^- \rightarrow Fe$	-0.44
Ni	$Ni^{2+} + 2e^- \rightarrow Ni$	-0.25
Sn	$Sn^{2+} + 2e^- \rightarrow Sn$	-0.14
H_2	$2H^+ + 2e^- \rightarrow H_2$	0.00
Cu	…	+0.34
I_2	…	+0.54
Ag	…	+0.80
Cl_2	…	+1.36
F_2	…	+2.87

Table B7.2

Predicting Displacement Reactions

The electrochemical series help us to predict whether displacement reactions can occur.

Metallic elements having lower reduction potential will lose electrons more readily and will displace elements having higher reduction potential from its salt solution. For example, zinc will displace copper from its salt solution because it has E^o value of -0.76V while copper has E^o value of +0.34V

On the contrary, non-metallic elements with higher reduction potential will displace other non-metallic elements with lower reduction potential.

For displacement of hydrogen from dilute acids by metals, the metal which can provide electrons to H^+ ions present in dilute acids for reduction, evolve hydrogen from dilute acids. Metals having negative values of reduction potential possess the property of losing electron(s).

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Determining the Products of Electrolysis

In the event that two or more positive ions are present in the solution during electrolysis, the ion which is the stronger oxidising agent or has the higher value of standard reduction potential is discharged first at the cathode. For example, in a solution containing potassium and silver ions, silver ions are discharged first.

(a) It is difficult to set up the Na/Na^+ and K/K^+ half cells to measure their E° value and hence sometimes scientists have to conduct indirect experimental methods and perform calculations to estimate these values.
Explain why it is difficult to set up these half cells.

_____

_____ [1]

(b) **(i)** With reference to Table B7.2, construct the electrode equation for I_2.

_____ [1]

(ii) Using the reaction between chlorine and aqueous solution containing iodide ions as an example, explain why '*non-metallic elements with higher reduction potential displace other non-metallic elements with lower reduction potential*'.

_____

_____

_____ [1]

(c) Which of the following displacement reactions is likely to occur?
Put a tick (√) if a reaction is likely to occur.

	chromium	tin
aqueous solution of nickel(II) ions		
aqueous solution of iron(II) ions		
dilute nitric acid		

[2]

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(d) Describe how the trend in reactivity of Group I and Group VII elements compare to their trends in standard reduction potentials as shown in Table B7.2.

_____

_____

_____

_____

_____ [3]

(e) Complete the following table for the electrolysis of different aqueous solutions using platinum electrodes.

solutions	name of products of electrolysis that would be produced first		ionic equation for the reaction at each electrode
concentrated magnesium chloride	at negative electrode		
	at positive electrode		
mixture of aqueous silver nitrate and aqueous copper(II) chloride	at negative electrode		
	at positive electrode		

[4]

[Total:12]

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B8 Nitrogen monoxide and hydrogen reacts at 400 °C according to the following equation.

$$2NO\ (g) + 2H_2\ (g) \rightarrow N_2\ (g) + 2H_2O\ (g)$$

Different initial concentrations of nitrogen monoxide and hydrogen were used to investigate the rate of reaction. In each experiment, the initial rate of reaction was measured.

Table B8.1 shows the results obtained in each experiment.

experiment	initial concentration of NO / mol dm^{-3}	initial concentration of H_2 / mol dm^{-3}	initial rate of reaction / mol dm^{-3} s^{-1}
1	0.0060	0.0010	1.8×10^{-4}
2	0.0060	0.0020	3.6×10^{-4}
3	0.0010	0.0060	0.3×10^{-4}
4	0.0020	0.0060	1.2×10^{-4}
5	0.0040	0.0030	?

Table B8.1

(a) A student makes the following statement.

> Increasing the concentration of NO increases the rate of reaction to a greater extent than increasing the concentration of H_2.

Does the information in the table support the statement made by the student? Explain your reasoning.

_____

_____

_____

_____

_____

_____ [3]

(b) Experiment 5 was conducted using 0.0040 mol dm^{-3} of NO and 0.0030 mol dm^{-3} of H_2. Predict the initial rate of formation of N_2.

_____ [1]

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(c) Calculate the final volume of gases remaining in the reaction vessel when 20 cm^3 of NO reacted with 15 cm^3 of H_2 at 400 °C.
Show all working clearly.

[2]

(d) Explain, in terms of collisions between (reacting) particles, how operating at a lower temperature of 250 °C affects the rate of reaction in the reactor.

[2]

[Total: 8]

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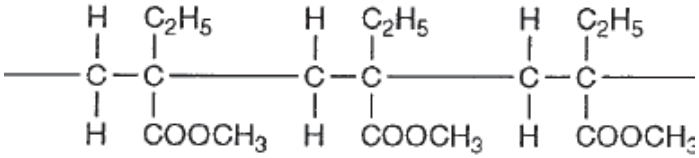
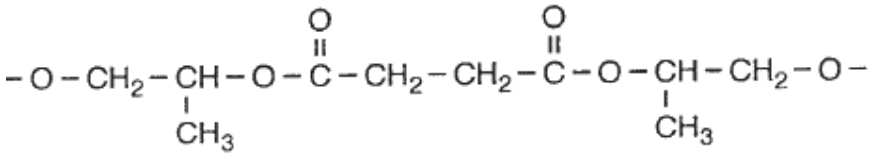
B9 ***Either***

The structures of two polymers X and Y are shown below.

polymer X	
polymer Y	

(a) A potential customer requires the chain length of the polymer X to be controlled so that the polymer molecules have an average relative molecular mass in the range of 20 000 to 50 000.

What is the range of the average number of repeat units in the polymer molecules? Show your working.

[2]

(b) **(i)** Draw the structural formulae of the monomers where polymer Y could be made from.

[2]

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(ii) Calculate the mass of polymer Y produced when 1 kg of each of the monomers reacted.

[3]

(c) Describe three differences between polymer X and polymer Y.

_____

_____

_____

_____

_____ [3]

[Total: 10]

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B9 *OR*

Figure B9.1 shows the Haber process.

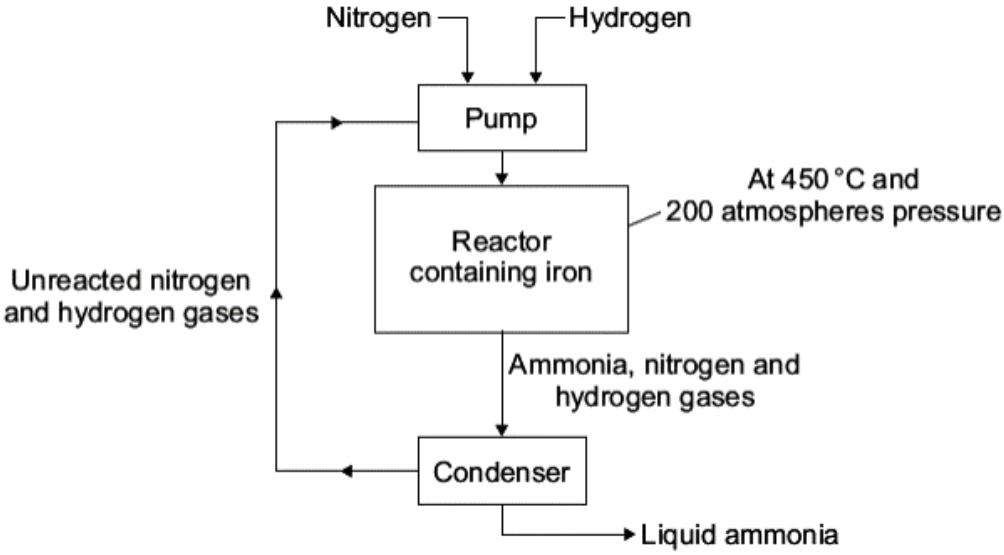

Figure B9.1

Figure B9.2 shows the yield of ammonia that is made under different conditions.

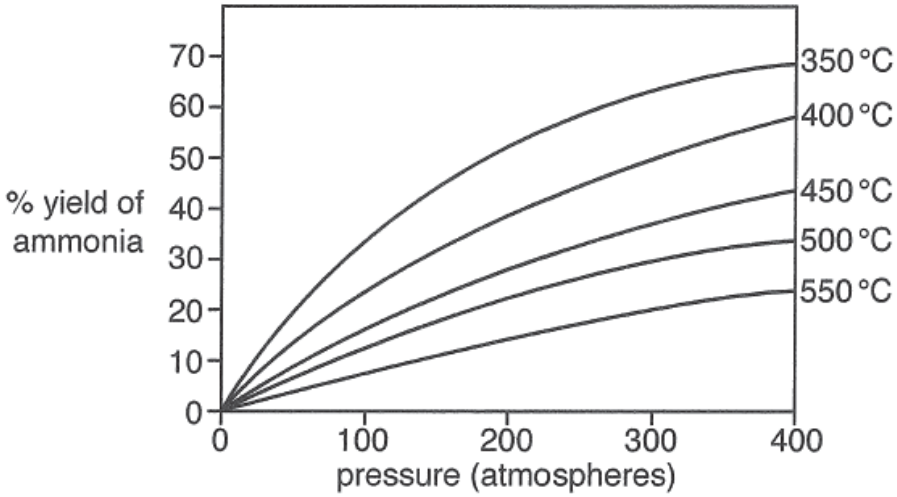

Figure B9.2

(a) In present times, the Haber process has been adapted to work at a lower temperature of 250 °C. Predict and explain how a lower temperature affects the relative amounts of ammonia, nitrogen and hydrogen that leaves the reactor.

_____

_____

_____ [2]

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(b) In the condenser, ammonia is separated out as a liquid. Explain how this is achieved.

_____

_____ [1]

(c) The percentage yield for the production of ammonia is typically low. Explain why.

_____

_____ [1]

(d) 60 dm^3 of nitrogen and 60 dm^3 of hydrogen were each pumped into the reactor The volume of ammonia produced was found to be 6 dm^3.
Calculate the percentage yield of ammonia for the reaction.

[2]

(e) Aqueous ammonia is formed when ammonia gas is dissolved in water. When aqueous ammonia is added dropwise until excess to a sample of contaminated water, a mixture of white and blue precipitate was formed initially. The resulting mixture was a dark blue solution.
State the formula(e) of the possible cations present in the water sample.

_____ [2]

(f) Ammonium nitrate is a common fertiliser used by farmers. Rain water can wash ammonium nitrate off the farmland and into rivers and lakes. Ammonium nitrate in drinking water supplies is harmful to health.
Describe tests to identify the presence of ammonium nitrate in drinking water.

_____

_____

_____

_____ [2]

[Total: 10]

End of Paper

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The Periodic Table of Elements

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

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 –		

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.).

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