LOYANG VIEW SECONDARY SCHOOL

Preliminary Examination 2022
Secondary Four Express

CANDIDATE NAME : .....

CLASS : ..... **INDEX NUMBER** : .....

CHEMISTRY 6092/02

Paper 2 Theory **29 August 2022**

1 hour 45 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, highlighters, glue or correction fluid.

Section A
Answer **all** questions.

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.
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**

Setter: Mrs Lam-Tan Siok Hiang

Section A

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

1 Iron is extracted from iron ore in the blast furnace.

The equations **A, B, C, D** and **E** show some reactions that happen in the blast furnace.

A $C + O_2 \rightarrow CO_2$

B $CO_2 + C \rightarrow 2CO$

C $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

D $CaCO_3 \rightarrow CaO + CO_2$

E $SiO_2 + CaO \rightarrow CaSiO_3$

(a) Use the letters **A**, **B**, **C**, **D** and **E** to answer the following questions.

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

(i) Which equation shows neutralisation?

…….. [1]

(ii) Which equation shows an element that undergoes both oxidation and reduction at the same time?

…….. [1]

(iii) Which equation shows no change in the oxidation state of any element in the reactants?

…….. [1]

(b) Blast furnace slag may contain impurities of Group IV and Group V oxides.

These impurities cause the slag to be less effective in removing acidity from the soil.

Explain why Group IV and Group V oxides are less effective in removing acidity.

……...

……... [1]

[Total: 4]

2 Two students want to distinguish between two unlabelled test tubes each containing either aqueous sodium hydroxide or aqueous ammonia.

Student **A** suggests adding aqueous zinc nitrate while student **B** suggests adding aqueous lead(II) nitrate into both test tubes.

(a) Which student would be able to distinguish between the two unlabelled test tubes? Use the observations obtained by both students to support your answer.

……

……

……

……

……

……

…… [2]

(b) Aqueous ammonia can be used to make fertilisers such as ammonium nitrate. Ammonium nitrate is slightly acidic.

Calcium carbonate can be added to the fertiliser so that soil does not become acidic, but calcium hydroxide should not be used.

Explain why calcium hydroxide should **not** be added to ammonium nitrate fertiliser.

……

……

……

…… [2]

[Total: 4]

3 Some elements have many isotopes.

Table 3.1 shows information about three atoms of element **X**.

Table 3.1

atom	**1**	**2**	**3**
number of protons	7	7	7
number of electrons	7	7	7
number of neutrons	7	8	9
number of electrons in outer shell	5	5	5

(a) Use data from Table 3.1 to show that atoms 1, 2 and 3 are isotopes of the same element.

……

……

…… [1]

(b) Explain how the data suggests that the three isotopes undergo the same types of chemical reactions.

……

…… [1]

(c) Elements **Y** and **Z** also have isotopes**.**

Table 3.2 shows information about the isotopes of elements **Y** and **Z**.

Table 3.2

	isotope of element **Y**	isotope of element **Z**
number of protons	53	38
number of electrons	53	38
number of neutrons	66	50
number of electrons in outer shell	7	2

(i) Use the information in Table 3.1, Table 3.2 and the Periodic Table to identify the elements **X**, **Y** and **Z**.

X ……..

Y ……..

Z …….. [1]

(ii) Suggest the trend in the melting points of elements **X**, **Y** and **Z**.

lowest melting point ……

……

highest melting point …… [1]

Explain your reasoning.

……

……

……

……

……

……

…… [3]

(iii) Which of the elements, **X**, **Y** or **Z**, reacts with acids to form a salt?

Explain your reasoning.

……

……..... [1]

[Total: 8]

4 The reaction between dilute hydrochloric acid and aqueous sodium hydroxide releases 57.3 kJ of energy when one mole of water is formed.

(a) Write the ionic equation of the reaction.

…… [1]

(b) **(i)** 200 cm^3 of 0.200 mol/dm^3 dilute hydrochloric acid reacts with 100 cm^3 of 0.150 mol/dm^3 aqueous sodium hydroxide.

Calculate the overall enthalpy change of this reaction

overall enthalpy change = ……kJ [2]

(ii) In a separate reaction, the same volume and concentration of dilute sulfuric acid is used instead of dilute hydrochloric acid.

State and explain whether this affects the overall enthalpy change of the reaction.

…….

…….

……. [2]

(c) Draw a labelled energy profile diagram for the reaction between dilute hydrochloric acid and aqueous sodium hydroxide.

Your diagram should include:

- the formulae of the reactants and products
- the enthalpy change
- the activation energy

[3]

[Total: 8]

5 Bromomethane, CH_3Br, is a poisonous organic compound.

It is used to kill pests such as rats and bugs.

(a) Draw a 'dot and cross' diagram to show the bonding in bromomethane.

Show the outer shell electrons only.

[2]

(b) Determine if the following statements about bromomethane are true or false.

Put a tick (✓) in one box for each statement.

	true	false
Bromomethane has a low boiling point.		
Bromomethane has good electrical conductivity when molten.		
Bromomethane could be obtained through the substitution reaction of methane and bromine.		

[3]

(c) Bromine reacts with sodium to form sodium bromide.

Draw a 'dot and cross' diagrams to show the arrangement of outer shell electrons in sodium bromide.

[2]

[Total: 7]

6 The table shows some information about a homologous series called ethers.

name	number of carbon atoms	formula	boiling point / °C
methoxymethane	2	CH_3OCH_3	−24.8
methoxyethane	3	$CH_3OC_2H_5$	7.0
methoxypropane	4	$CH_3OC_3H_7$	
	5		70.3

(a) Deduce the name and formula of the ether that contains 5 carbon atoms.

name ……..……...

formula ……. [2]

(b) **(i)** Suggest a value for the boiling point of methoxypropane.

……. [1]

(ii) Account for the changes in boiling point down the group.

……

……

……. [2]

……

(c) Besides boiling point, suggest how another physical property of this homologous series changes down the group.

..……. [1]

(d) How does the data in the table show that the compounds are from the same homologous series?

……...…

[1]

……...……

(e) Methoxymethane has an isomer which belongs to a homologous series that has the hydroxyl functional group.

Name this isomer and draw its structural formula.

name ……..……

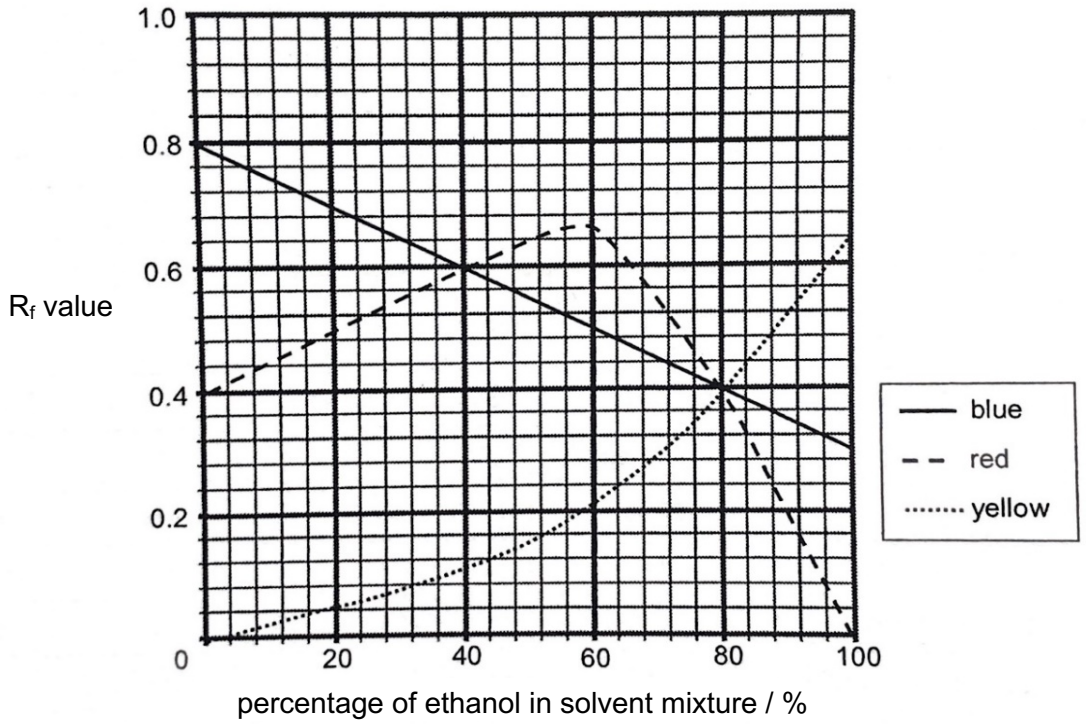
structural formula

[2]

[Total: 9]

7 A sample of black ink contains a mixture of red, blue, and yellow dyes. A common solvent used to separate the dyes in black ink is a mixture of ethanol and water. The coloured dyes have different R_f values in solvents with different composition of ethanol as shown in Fig. 7.1

Fig. 7.1



(a) (i) How many spots will be shown on the chromatogram when the solvent used consists of 40% ethanol in the solvent mixture?

…… [1]

.

(ii) With reference to Fig 7.1, explain why 40% ethanol in the solvent mixture is not suitable for the separation of black ink.

……

.

[1]

……

.

(b) (i) Calculate the percentage of ethanol in a solvent mixture of 32 cm^3 of ethanol and 168 cm^3 of water.

percentage of ethanol [1]
= …….....%

(ii) Hence state the R_f value of the blue dye on the chromatogram in the percentage of ethanol calculated in **(b)(i)**.

……. [1]
.

[Total: 4]

8 Smartphones are pocket-sized vaults of precious metal and rare earth elements.

A mobile phone is estimated to house around 0.034 g of gold, 0.34 g of silver, 0.015 g of palladium and less than one-thousandth of a gram of platinum. It also contains the less valuable but still significant aluminium (25 g) and copper (about 15 g).

Table 8.1 shows the top few metals used in the manufacturing of mobile phones and their extraction methods.

Table 8.1

metal	uses	extraction method	electrical conductivity/ s/m
Gold, Au	to make circuit boards	leaching using cyanide	42.6×10^6
Tin, Sn	acts as a solder to join parts in phones and camera modules	metal ores are smelted with carbon	9.1×10^6
Lithium, Li	to produce lithium batteries	electrolysis of concentrated lithium chloride	11.1×10^6
Aluminium, A*l*	to make mobile phone casings and components	electrolysis of molten bauxite (aluminium oxide)	37.7×10^6
Cobalt, Co	to make rechargeable batteries in mobile phones	metal ore are smelted with carbon	11.7×10^6
Copper, Cu	to make circuit boards	metal ore are smelted with carbon	59.8×10^6
Nickel, Ni	used in electrical connections, capacitors and batteries	metal ore are smelted with carbon	14.6×10^6
Silver, Ag	to make circuit boards	heating the ore	62.9×10^6
Zinc, Zn	to make circuit boards and added to aluminium to strengthen mobile phone casings	metal ore are smelted with carbon	16.9×10^6

(a) Explain what is meant by an ‘element.’

…………………..………………………………………………………………………..

……………..…………………………………………………………………………….. [1]

(b) A student reported that the electrical conductivity of a metal is linked to the reactivity of the metal.

Do you agree? Explain your answer using the information in Table 8.1.

……..……..

……..……..……

……..……..……

……..……..

……..……..……

……..……. [2]

(c) Based on the information given in Table 8.1, suggest a reason why aluminium is not used in the circuit even though it has a high electrical conductivity.

……

……..….. [1]

(d) Explain how the addition of zinc strengthens the aluminium casings for mobile phones.

……..……..

……..……..

……..……..

……..…….. [2]

[Total: 6]

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.

9 **The Processing of Crude oil**

The relative demand for fuel far outstrips the supply from the primary distillation of crude oil. Consequently, methods have been developed to convert the higher boiling, and more abundant, fractions into petrol by cracking through two alternative processes. The difference between these can be illustrated using dodecane as an example.

Thermal Cracking

Thermal cracking involves heating the alkane mixture to about 800 °C and at moderate pressure, in the absence of air but in the presence of steam. After only a fraction of a second at this temperature, the mixture is rapidly cooled. By this means, dodecane will typically be broken to form hexane and ethene:

$$CH_3(CH_2)_{10}CH_3 \rightarrow CH_3(CH_2)_4CH_3 + 3CH_2CH_2$$

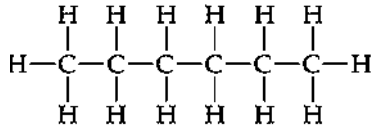
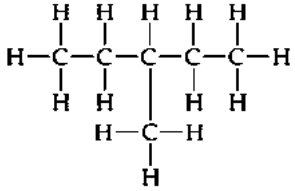
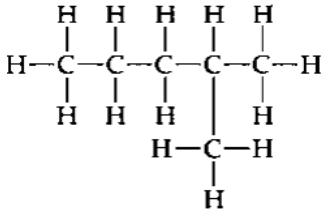
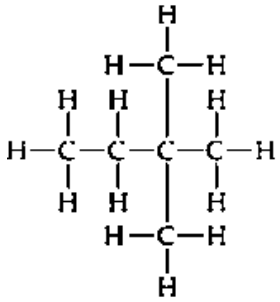
Catalytic Cracking

Catalytic cracking involves heating the alkane mixture to a temperature of 500 °C and passing it under slight pressure over a catalyst made from a porous mixture of aluminium and silicon oxides (called zeolites). By this means, isomers of hexane and ethene are produced:

$$2CH_3(CH_2)_{10}CH_3 \rightarrow (CH_3)_2CHCH_2CH_2CH_3 + (CH_3)_2CHCH(CH_3)_2 + 6CH_2CH_2$$

Table 9.1 shows melting points and boiling points of some isomers of hexane.

Table 9.1

compound	structural formula	boiling point / °C
hexane		68
3-methylpentane		63
2-methylpentane		60
2,3-dimethylbutane		58

(a) There is a large demand for the molecules in crude oil that can be used to make petrol. Both cracking processes are important to make sure that supply meets demand.

(i) Explain how cracking helps to meet the demand for petrol.

……..

…….. [1]

(ii) Explain an advantage that catalytic cracking has over thermal cracking.

……..

…….. [1]

(b) Ethene can undergo addition polymerisation to form a polymer.

(i) Draw two repeating units of the polymer formed by ethene.

[1]

(ii) Suggest a use of the polymer you have drawn in part **(b)(i)**.

…….. [1]

(c) How is the boiling point of alkanes affected by isomerisation?

Use evidence from the information to explain your reasoning.

……..……..

……..……..

……..……..

……..……..

……..……..

……..…….. [3]

(d) Describe a test to distinguish between hexane and ethene. Include the results that would be obtained.

……..……..

……..……..

……..……..

……..…….. [2]

(e) Carbon is formed during catalytic cracking and this can coat the surface of the solid catalyst used.

Explain how a coating of carbon affects the efficiency of the catalyst used.

…….

……. [1]

(f) Other than petrol, ethanol can be used as a car fuel.

In some countries, it is produced from the sugars in sugar cane.

An environmentalist claims that ethanol as a fuel is 'carbon neutral' because using it does not add to the amount of carbon dioxide in the atmosphere.

Explain why this is true.

……

……

……

…… [2]

[Total: 12]

10 Mendeleev devised the modern Periodic Table, where he placed the elements in the same group if their properties were similar. When each Group VII element is allowed to react with vanadium under similar conditions of high temperature and pressure, the following results are obtained.

element	main product formed	colour of product
fluorine	VF_5	colourless
chlorine	VCl_4	bright red
bromine	VBr_3	red brown
iodine	VI_2	red violet

(a) Vanadium is a transition metal because it is able to exhibit variable valencies.

Use the data above to explain why vanadium is a transition metal.

……

…… [1]

(b) Do the formulae of the products in the table show clearly that all the elements belong to the same group?

Explain your reasoning.

……

…… [1]

(c) Group VII elements behave as oxidising agents in their reactions with vanadium.

(i) Explain, using ideas of oxidation states, how the given information shows that the oxidising strength of the halogens decreases down the group.

……..

……..

……..

…….. [2]

(ii) Based on your knowledge of the trend in the reactivity of Group VII, suggest a possible reason for the decreasing oxidising strength of halogens down the group.

……..

……..

…….. [1]

(d) Vanadium is transition metal that can exhibit a total of four different valencies.

Suggest the formula of a product formed when vanadium reacts with astatine.

……. [1]

(e) Zinc is a special transition metal.

(i) State one property of zinc which is not typical of a transition metal.

…… [1]

(ii) Zinc forms an oxide which is said to be amphoteric.

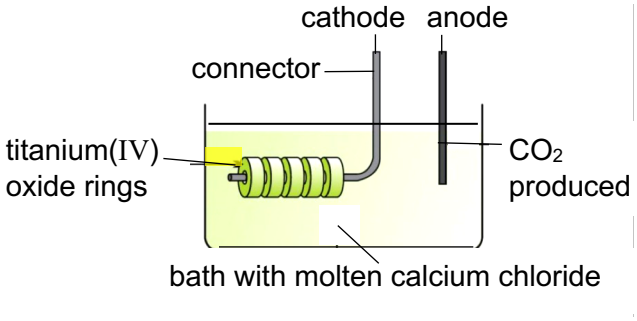
Explain why zinc oxide is classed as an amphoteric oxide.

…….. [1]

[Total: 8]

Either

11 The diagram below shows a new process that uses electrolysis for the direct reduction of solid titanium(IV) oxide (TiO_2) to extract titanium metal. Titanium has many desirable properties. It is light, strong and corrosion-resistant. Its use has been restructured because of the high processing cost of current extraction methods.



A voltage is set up between the cathode and anode. The titanium(IV) oxide gains electrons and releases oxide ions, which dissolve into the molten calcium chloride bath leaving pure solid titanium metal at the cathode. At the same time, oxide ions are discharged at the anode to form oxygen gas which then reacts with the carbon anode to form carbon dioxide. The process takes place between 900 °C and 1100 °C.

(a) Write the ionic equation, with state symbols, for the reaction occurring at the cathode.

…… [2]

(b) Suggest why the electrolysis cell needs to be operated at a temperature of between 900 °C to 1100 °C?

……

…… [1]

(c) What is the purpose of the molten calcium chloride bath?

……

…… [1]

(d) Write the ionic equation, with state symbols, for the formation of oxygen gas at the anode.

…… [2]

(e) In an industrial process, 4.8 tonnes of the titanium(IV) oxide rings was used.

Calculate the maximum mass of titanium metal that can be extracted.

maximum mass of titanium metal = ... tonnes [2]

(f) At the start of the electrolysis, it was noticed that the gas formed was not colourless.

Name this gas and explain why it was formed initially.

……

……

…… [2]

[Total: 10]

OR

12 Coal-burning power stations produce sulfur dioxide and oxides of nitrogen. The two gases cause acid rain.

(a) Nitric oxide, NO, is formed in a power station when nitrogen and oxygen react.

Write the equation for this reaction.

…… [1]

(b) Many coal burning power stations are now fitted with a flue gas desulfurisation plant which removes sulfur dioxide and nitrogen dioxide from the gaseous emissions.

In a flue gas desulfurisation plant, powdered calcium carbonate reacts with sulfur dioxide as shown below.

$$SO_2(g) + CaCO_3(s) \rightarrow CaSO_3(s) + CO_2(g)$$

(i) State the nature of calcium carbonate which enables it to react with sulfur dioxide.

…….. [1]

(ii) Explain why the calcium carbonate used is in powdered form.

……..

…….. [1]

(iii) Calculate the volume of sulfur dioxide that can be removed with 20 kg of calcium carbonate which contains 10% impurities.

volume of sulfur dioxide = ……..... dm^3 [2]

(iv) State a chemical test for sulfur dioxide.

……..

…….. [1]

(c) In the air, sulfur dioxide reacts with nitrogen dioxide forming sulfur trioxide.

The reaction that takes place are shown in the equation.

reaction 1 $SO_2 + NO_2 \rightarrow SO_3 + NO$

reaction 2 $2NO + O_2 \rightarrow 2NO_2$

(i) In which reaction, 1 or 2, is nitrogen reduced?

Explain your answer in terms of oxidation states.

……..

……..

……..

…….. [2]

(ii) Nitrogen monoxide is also an atmospheric pollutant. It is found in car exhaust. It is removed from car emissions by the catalytic converter in the car. Nitrogen monoxide reacts with carbon monoxide to produce a mixture of two gases.

Write a chemical equation for this reaction.

……. [1]

(iii) While the catalytic converter can help to remove nitrogen monoxide and carbon monoxide from the car exhaust, explain why the gases released by the converter could still harm the environment.

……..

[1]

……..

[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.).