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Name:	Class	Index Number

Jurong West Secondary School

Preliminary Examinations 2018

40

CHEMISTRY **6092/01**

Secondary Four Express **17 August 2018**

Paper 1 **1130 - 1230**

1 hour

Candidates answer on the Multiple Choice Answer Sheet.

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write your name, class and index number on all the work you hand in.
Write in soft pencil.
You may use an HB pencil for any diagrams, graphs, tables or rough working.
Do not use staples, paper clips, glue or correction fluid.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

There are **forty** questions. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet. **Read the instructions on the Answer Sheet very carefully**. Each correct answer will score one mark. A mark will not be deducted for a wrong answer. Any rough working should be done in this question paper.

A copy of the Periodic Table is printed on page 15.

After checking of answer script		
Checked by Student	**Signature**	**Date**

This document consists of **15** printed pages.

Setter: Mr Edwin Kwek

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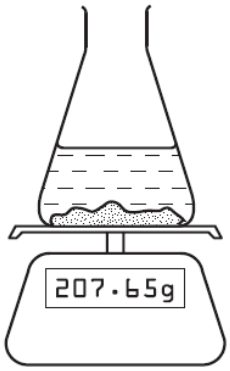
1 Calcium carbonate reacts with hydrochloric acid, producing carbon dioxide gas.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

The rate of this reaction can be measured using the apparatus shown.

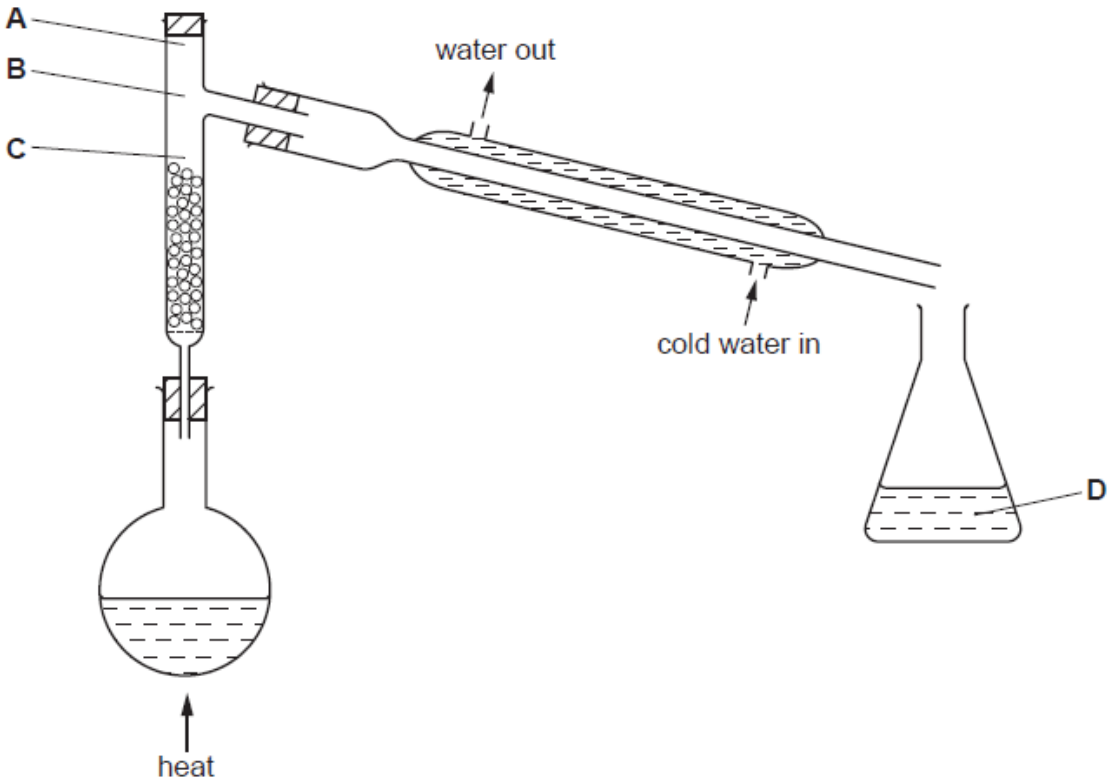


Which additional piece of apparatus is also required?

A a burette
B a clock
C a gas syringe
D a thermometer

2 The fractional distillation apparatus shown is being used to separate a mixture of two liquids. A thermometer is missing from the apparatus.

Where should the bulb of the thermometer be placed?



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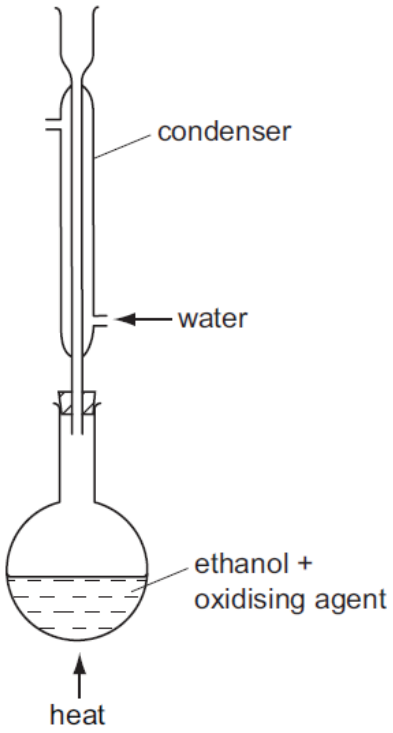
3 The oxidation of ethanol to ethanoic acid is often carried out in the apparatus shown.



What is the purpose of the condenser?

A to prevent any ethanol from escaping
B to prevent air from reacting with the ethanoic acid
C to prevent the ethanoic acid from reacting with the ethanol
D to prevent the ethanoic acid from changing back to ethanol

4 The table shows the results of two reactions of an aqueous solution of a salt.

reagents	final observation
excess aqueous sodium hydroxide	white precipitate
dilute nitric acid and aqueous silver nitrate	yellow precipitate

What is the name of the salt?

A calcium chloride
B calcium iodide
C zinc nitrate
D zinc sulfate

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5 Which property or properties will affect the rate of diffusion of gases?

1 Temperature
2 Solubility
3 Molecular mass

A 1 only
B 1 and 2
C 1 and 3
D All of the above

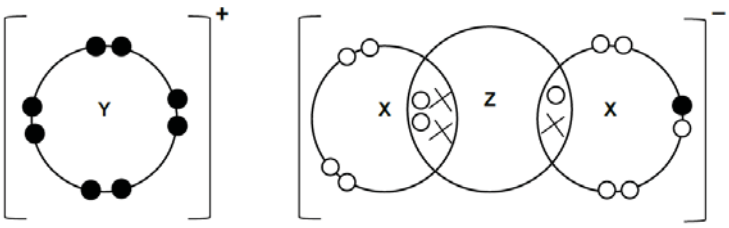
6 Alpha particles consist of two protons and two neutrons bound together into a particle identical to a helium-4 nucleus.

In the Rutherford gold foil experiment, a thin piece of pure gold foil was used. After alpha particles were shot at gold foil, scientists noticed only a tiny fraction of the alpha particles were deflected by a large angle. Most flew straight through the foil.

Suggest a reason for this phenomenon.

A The gold atoms consist of a small positively charged nucleus with large, empty spaces between the nucleus.
B The gold atoms consist of a small negatively charged nucleus with large, empty spaces between the nucleus.
C The gold atoms are surrounded by small positively charged electrons with large, empty spaces between the electrons.
D The gold atoms are surrounded by small negatively charged electrons with large, empty spaces between the electrons.

7 X, Y and Z are 3 different elements in the Periodic Table. The 'dot-and-cross' diagram of the compound formed from X, Y and Z is shown below. Only the valence electrons are shown.



Which statements are correct?

1 Element Y could be lithium.
2 Element X belongs to Group VI of the Periodic Table.
3 Elements X and Z are bonded together by covalent bonds.
4 There are more electrons than protons in ZX_2^-.

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

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8 The table below shows the number of neutrons and electrons in the following four particles.

Particle	Number of neutrons	Number of electrons
W	18	8
X^+	12	10
Y^{2-}	16	10
Z	13	11

Which of the following atoms is an isotope of W?

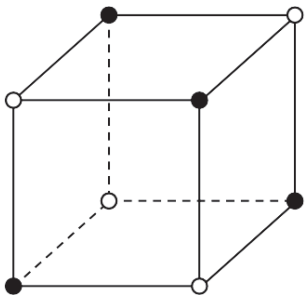
A X

B Y

C Z

D None of the above

9 The diagram shows the arrangement of the ions in an ionic crystal.



Key

○ = positive ion

● = negative ion

Which substance **cannot** have this arrangement of its ions?

A $CuSO_4$

B KC*l*

C MgO

D Na_2S

10 Which of the following correctly describes the particles in a **very dilute** sodium chloride solution at room temperature?

	ions of sodium chloride	water molecules
A	widely separated, moving at random	close together, moving at random
B	widely separated, vibrating about fixed positions	close together, moving at random
C	close together, moving at random	widely separated, moving at random
D	close together, vibrating about fixed positions	widely separated, moving at random

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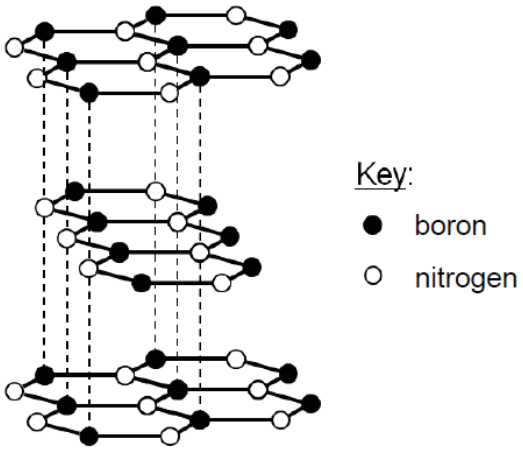
11 The table gives the properties of four substances.
Which substance is a solid metal at room temperature?

	melting point / °C	boiling point / °C	electrical conductivity when solid	electrical conductivity when molten
A	808	1465	×	✓
B	98	890	✓	✓
C	119	445	×	×
D	-39	357	✓	✓

key
✓ = conducts
× = does not conduct

12 The diagram shows the structure of hexagonal boron nitride.



Which property is hexagonal boron nitride most likely to have?

A It is soluble in water.
B It has a low melting point.
C It is soft and acts as a lubricant.
D It does not conduct electricity in solid state but conducts electricity in liquid state.

13 Which statement is **not** true for all metals when they are in solid state?

A They conduct heat.
B They are malleable.
C They conduct electricity.
D They form coloured compounds.

14 All of the following substances can conduct electricity.
Which substance's conductivity is not due to the movement of electrons?

A aluminium
B graphite
C lithium chloride
D mercury

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15 One mole of a sample of hydrated sodium sulfide contains 162 g of water of crystallisation. What is the correct formula of this compound?

A $Na_2S.3H_2O$
B $Na_2S.5H_2O$
C $Na_2S.7H_2O$
D $Na_2S.9H_2O$

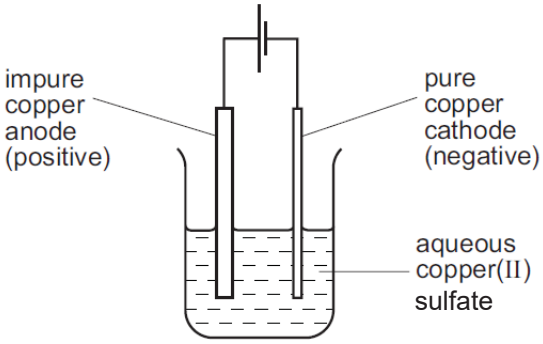
16 Hydrogen reacts with oxygen as shown in the equation below.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$$

How much gas will remain if 2 dm^3 of hydrogen are reacted with 1 dm^3 of oxygen at room temperature?

A 0 dm^3
B 1 dm^3
C 2 dm^3
D 3 dm^3

17 A sample of copper contains a metal impurity which is below copper in the reactivity series. The diagram shows the apparatus used for refining the sample.



The loss in mass of the anode is 50 g and the gain in mass of the cathode is 45 g.

What is the percentage purity of this sample of copper?

A 10.0%
B 11.1%
C 90.0%
D 95.0%

18 What products are formed when concentrated aqueous potassium chloride is electrolysed?

	at the anode	at the cathode
A	chlorine	hydrogen
B	chlorine	potassium
C	oxygen	hydrogen
D	oxygen	potassium

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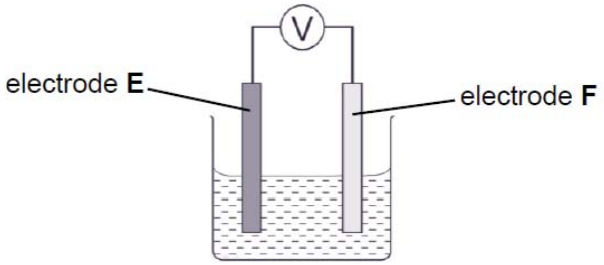
19 A galvanic cell is set up as shown below.



Which pair of electrodes would give the largest magnitude on the voltmeter reading?

	electrode E	electrode F
A	copper	zinc
B	magnesium	copper
C	silver	magnesium
D	zinc	iron

20 Which of the following is an endothermic reaction?

A the combustion of ethanol in air
B the oxidation of carbon to carbon dioxide
C the reaction between hydrogen and oxygen
D the formation of a carbohydrate and oxygen from carbon dioxide and water

21 Nitrogen and hydrogen react to give ammonia according to the equation.

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

The bond energy of some covalent bonds are shown below.

bond	bond energy (kJ/mol)
N≡N	945
H–H	436
N–H	391

What is ΔH, in kJ/mol, for the reaction above?

A –1471
B –93
C 93
D 1471

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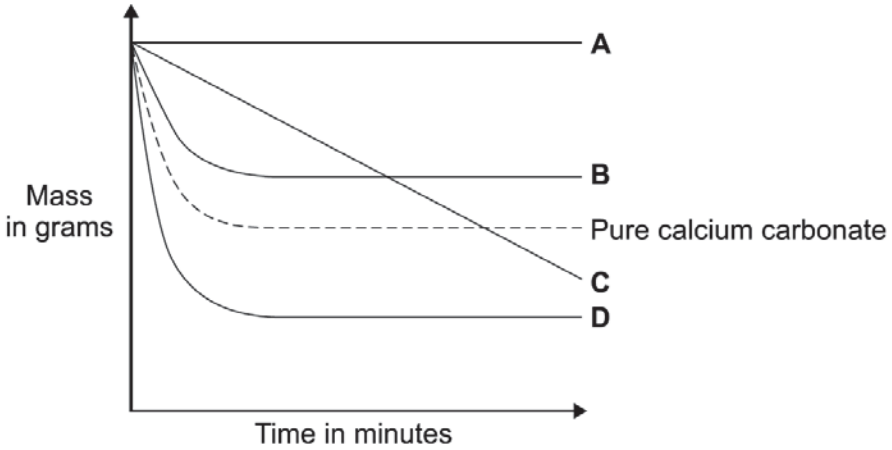
22 Limestone usually contains impurities.
The diagram below shows the change in mass when pure calcium carbonate is heated.
Which graph, **A**, **B**, **C** or **D**, shows a sample of limestone, of the same mass, containing impurities that do not thermally decompose?



23 The following changes could be made to the conditions in the reaction between zinc and hydrochloric acid.

1 increase in concentration of the acid
2 increase in particle size of the zinc
3 increase in pressure on the system
4 increase in temperature of the system

Which pair of changes will increase the rate of reaction?

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

24 Why is nickel used in the addition of hydrogen to alkenes?

A It increases the yield of products.
B It makes the reaction more exothermic.
C It prevents a reverse reaction from occurring.
D It lowers the activation energy of the reaction.

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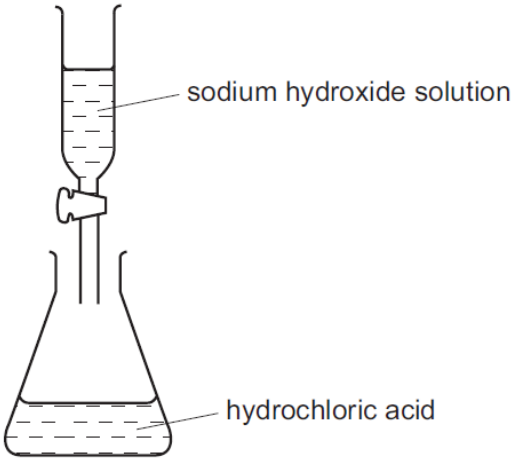
25 Iron is extracted from its ore haematite, Fe_2O_3, by a reduction process in the blast furnace.

Which equation for reactions in the blast furnace shows the formation of the reducing agent?

A $CaCO_3 \rightarrow CaO + CO_2$
B $CaO + SiO_2 \rightarrow CaSiO_3$
C $CO_2 + C \rightarrow 2CO$
D $C + O_2 \rightarrow CO_2$

26 Sodium hydroxide solution was added to dilute hydrochloric acid. The pH of the solution in the flask was measured at intervals until no further change of pH took place.



What would be the pH change in this reaction?

A decrease to 1
B decrease to 7
C increase to 7
D increase to 12

27 Which metal has a soluble carbonate, chloride and sulfate?

A barium
B calcium
C copper
D potassium

28 Which substance would **not** be used for preparing a pure sample of crystalline magnesium sulfate by reaction with dilute sulfuric acid?

A magnesium carbonate
B magnesium hydroxide
C magnesium nitrate
D magnesium oxide

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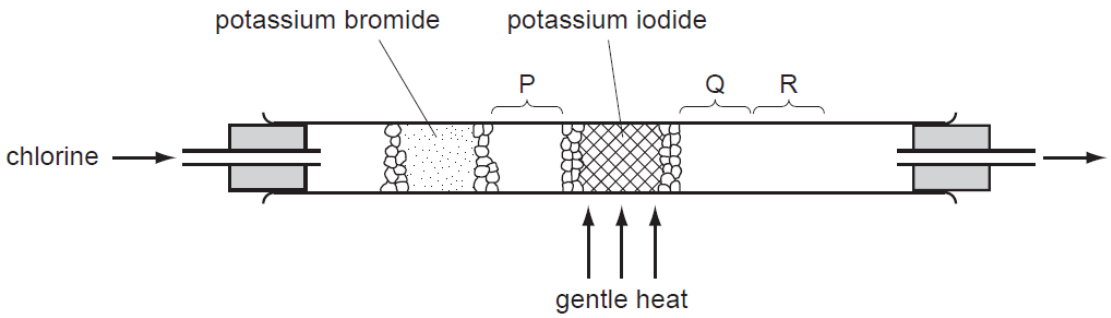
29 Which of the following methods would produce ammonia?

1 Heating aqueous barium nitrate with sodium hydroxide and aluminium powder.
2 Heating aqueous ammonium chloride with aqueous calcium hydroxide.
3 Heating solid ammonium sulfate with solid potassium hydroxide.
4 Heating aqueous ammonium chloride with dilute hydrochloric acid.

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

30 Using the apparatus shown, chlorine is passed through the tube.



After a short time, coloured substances are seen at P, Q and R.
What are these coloured substances?

	at P	at Q	at R
A	green gas	red brown vapour	violet vapour
B	green gas	violet vapour	black solid
C	red brown vapour	violet vapour	black solid
D	violet vapour	red brown vapour	red brown vapour

31 The table shows the reactions of metals **A**, **B**, **C** and **D** when placed in aqueous solutions of their nitrates.

metal	nitrate of **A**	nitrate of **B**	nitrate of **C**	nitrate of **D**
A	-	reacts	reacts	reacts
B	no reaction	-	reacts	no reaction
C	no reaction	no reaction	-	no reaction
D	no reaction	reacts	reacts	-

A mixture of aqueous solutions of nitrates of **A**, **B**, **C** and **D** are electrolysed using carbon electrodes.

Which metal ion of metals **A**, **B**, **C** or **D** would most readily be discharged at the negative electrode?

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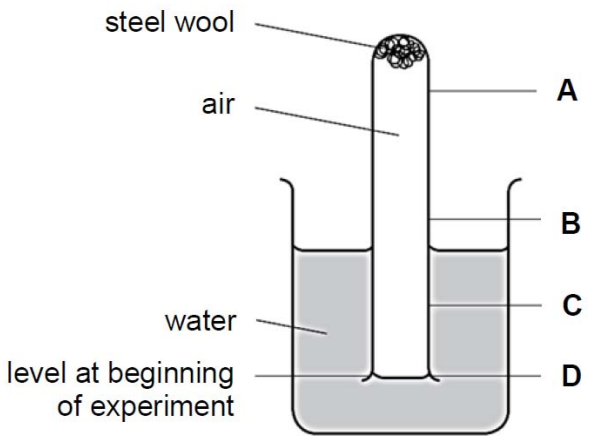
32 Experiments were carried out to determine the relative reactivity of three metals, S, T and U. The results were recorded in the table.

	metal S	metal T	metal U
Can the metal react with dilute hydrochloric acid?	yes	no	yes
Can the metal oxide be reduced by heating with carbon?	yes	yes	no

Which of the following shows the metals in order of **decreasing** reactivity?

A S, U, T
B T, S, U
C U, S, T
D U, T, S

33 The diagram shows steel wool inside a test-tube.



The test-tube is inverted in water, trapping air inside. What will be the water level inside the tube after several days?

34 The enthalpy change for the complete combustion of three different fuels, methane, ethanol and propene are as shown below.

fuel	formula	M_r	enthalpy change of combustion / kJ/mol
methane	CH_4	16	-100
ethanol	C_2H_5OH	46	-75
propene	C_3H_6	42	-170

What is the correct order of fuels, starting from the fuel that provides the most energy per gram of fuel, when the fuel undergoes complete combustion?

A methane, propene, ethanol
B methane, ethanol, propene
C propene, methane, ethanol
D ethanol, propene, methane

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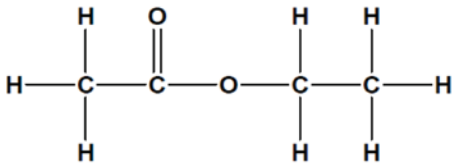
35 The table shows the boiling points of four fractions, P, Q, R and S, obtained when crude oil is distilled.

Fraction	P	Q	R	S
Boiling Range / ^{o}C	35-75	80-145	150-250	greater than 250

How is fraction P different from S?

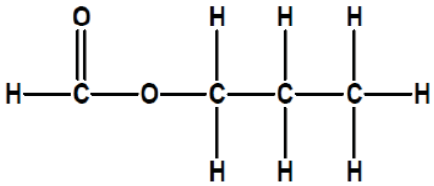
A Fraction P is more viscous than fraction S.
B Fraction P is in less demand than fraction S.
C Fraction P is more flammable than fraction S.
D Fraction P contains molecules of larger molecular masses than fraction S.

36 The diagram shows the structure of ethyl ethanoate.

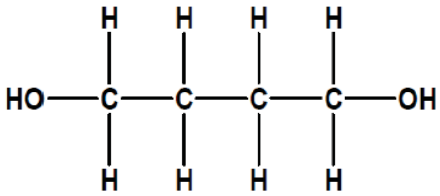


Which structure is **not** an isomer of ethyl ethanoate?

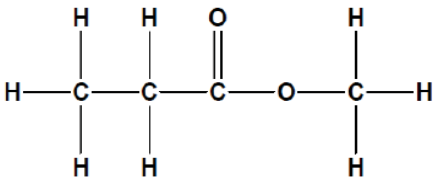
A



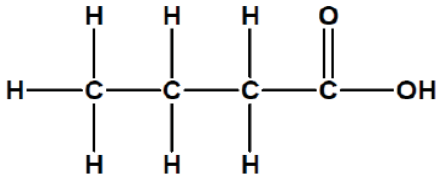
B



C



D



37 60 cm^3 of oxygen was mixed with 10 cm^3 of gaseous hydrocarbon in a closed vessel. After explosion and cooling, the gases occupied 50 cm^3 and after passing the gas through aqueous sodium hydroxide, 30 cm^3 of oxygen remained. Deduce the molecular formula of the hydrocarbon.

A CH_4
B C_2H_4
C C_2H_6
D C_3H_6

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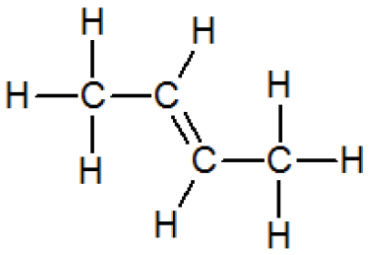
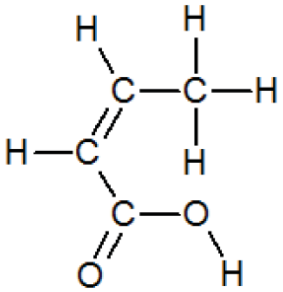
38 The full structural formulae of compounds X and Y are shown below.



Compound **X**



Compound **Y**

The **best** method to distinguish between X and Y visually is by using

A aqueous bromine
B potassium hydroxide solution
C potassium carbonate solution
D acidified potassium manganate(VII) solution

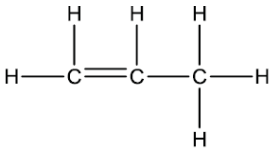
39 A food chemist wants to create the odour of pineapples for a product. An ester with this odour has the formula $C_3H_7CO_2C_4H_9$.

Which pair of substances will react to produce this ester?

A $C_2H_5CO_2H$ and C_4H_9OH
B $C_2H_5CO_2H$ and C_3H_7OH
C $C_4H_9CO_2H$ and C_3H_7OH
D $C_3H_7CO_2H$ and C_4H_9OH

40 Which compounds would undergo polymerisation on their own?

1



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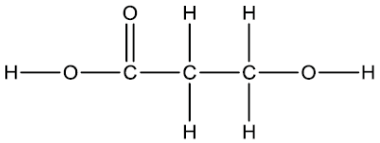

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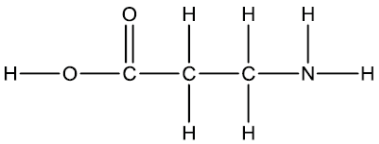

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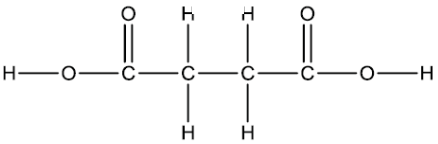

A 1 and 2 only
B 2 and 3 only
C 1, 2 and 3 only
D 1, 2, 3 and 4

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 Ba 137	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 Ba 137	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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Name:	Class	Index Number

Jurong West Secondary School

Preliminary Examinations 2018

80

CHEMISTRY 6092/02

Secondary Four Express **21 August 2018**

Paper 2 **0800 – 0945**

1 hour 45 minutes

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

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

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

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

Section B
Answer all **three** questions, the last question is in the form of 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 20.

After checking of answer script		
Checked by Student	**Signature**	**Date**

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

Setter: Mr Edwin Kwek

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Section A

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

A1 The diagram shows part of the Periodic Table. Only some of the elements are shown.

							H										
													C	N	O		
Na	Mg											Al	Si	P			
K	Ca						Fe			Cu	Zn						
Rb																	

Answer each of the following questions using only those elements shown in the diagram. Each element may be used once, more than once or not at all.

Give one element which

(a) has a giant molecular structure,

.....[1]

(b) combines with oxygen to form a gas which contributes to acid rain,

.....[1]

(c) forms an ion of type X^+ which has only three completely filled shells of electrons,

.....[1]

(d) has an atom with fourteen protons,

.....[1]

(e) can exist as two different allotropes in gaseous state,

.....[1]

(f) is the most reactive metal among the listed elements,

.....[1]

(g) has a chloride of type XCl_2, whose aqueous solution forms a green precipitate on addition of sodium hydroxide.

.....[1]

[Total: 7]

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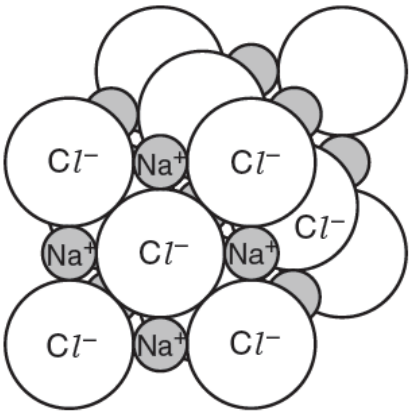
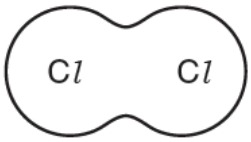
A2 The structures of sodium chloride and chlorine are shown below.



sodium chloride



chlorine

The melting point of sodium chloride is 801 °C.
The melting point of chlorine is –101 °C.

(a) Explain, in terms of structure and bonding, the difference between the melting points of these two substances.

.....

.....

.....

.....

..... [4]

(b) Predict whether magnesium oxide would have a higher or lower melting point than sodium chloride. Explain your answer in terms of bonding.

.....

.....

..... [2]

(c) Chlorine exists as a gas at room temperature while bromine exists as a liquid at room temperature. Explain your answer in terms of bonding.

.....

.....

..... [2]

[Total: 8]

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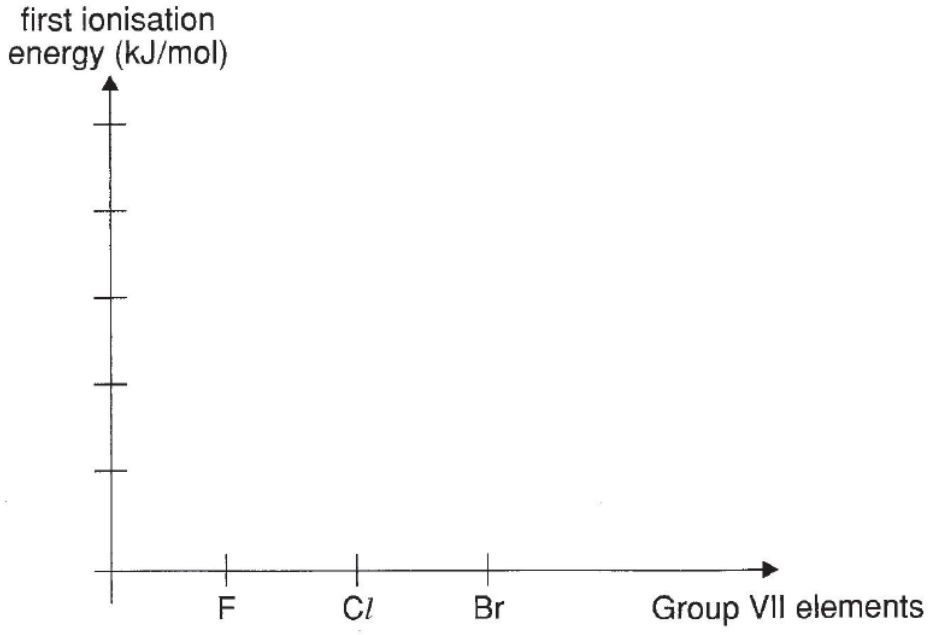
A3 First ionisation energy is the energy required to convert one mole of gaseous atoms into one mole of gaseous ions with a charge of +1.

The magnitude of the first ionisation energy increases in general as the number of electron shells decreases.

(a) **(i)** Draw, in the following graph, the trend in which the first ionisation energy changes down Group VII elements from fluorine to bromine.



[1]

(ii) Based on the trend of the change in first ionisation energy, suggest the relationship between the first ionisation energy and the reactivities of elements in Group VII.

..... [1]

(b) **(i)** What is observed if aqueous sodium iodide is reacted with aqueous chlorine?

..... [1]

(ii) Write an ionic equation, with state symbols, for the reaction in **(i)** above.

..... [2]

[Total: 5]

A4 The apparatus shown in the diagram was used to study the catalytic effect of certain

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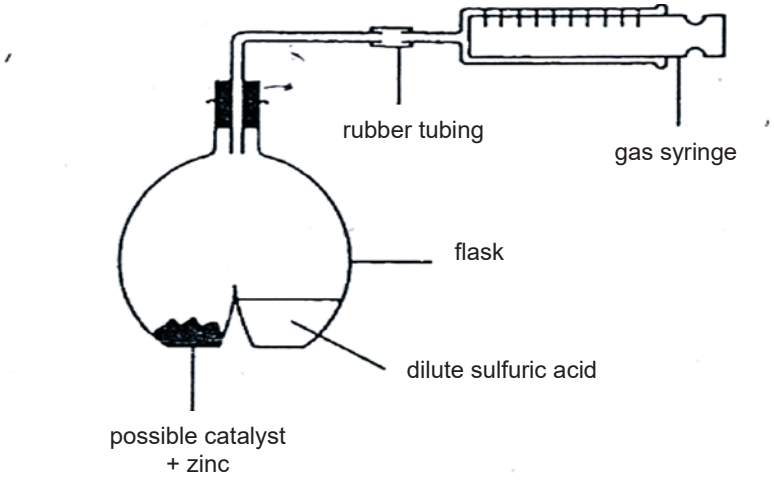
substances on the exothermic reaction between zinc and dilute sulfuric acid.

Several experiments were carried out. In each experiment, 50 cm^3 of 1.0 mol/dm^3 sulfuric acid, 1.0 g of zinc powder and 0.1g of a possible catalyst were used.



To start the reaction, the flask was shaken. The time taken to collect 50 cm^3 of hydrogen was recorded. Other observations are shown in the table.

Possible catalyst added	**Time to collect 50 cm^3 of hydrogen/s**	**Other observations**
No added catalyst	65	-
0.1 g of copper(II) sulfate	10	colourless solution obtained and a brown solid coated the zinc
0.1 g of copper(II) chloride	15	colourless solution obtained and a brown solid coated the zinc
0.1 g of copper powder	19	pink solid remained
0.1g of copper lumps	56	pink solid remained
0.1g of sodium chloride	65	colourless solution formed

(a) **(i)** Write the chemical equation for the reaction between zinc and dilute sulfuric acid.

..... [1]

(ii) Calculate the maximum volume of hydrogen gas that can be produced at

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room temperature and pressure in the reaction.

[3]

(b) Which of the added substances behaved as a catalyst? Explain your answer using information from the table.

.....

.....

..... [2]

(c) Explain, in terms of activation energy, how a catalyst speeds up a reaction.

.....

.....

..... [2]

(d) Suggest whether the time taken to collect 50 cm^3 of hydrogen would be longer or shorter than 65 s when 1.0 g of zinc lumps was used in the absence of a catalyst.

Explain your answer in terms of colliding particles.

.....

.....

..... [2]

[Total: 10]

A5 The graph below shows the percentage conversion to sulfur trioxide from sulfur dioxide

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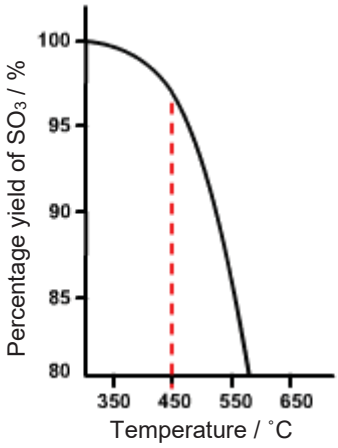
and oxygen gas during the Contact Process.



(a) Give two reasons, other than cost, why the optimal temperature for Contact Process is 450 ˚C.

.....

.....

..... [2]

(b) Write down the chemical equation for the formation of sulfur trioxide from sulfur dioxide and oxygen.

..... [1]

(c) Explain, in terms of bond breaking and bond forming, why the conversion of sulfur dioxide and oxygen to sulfur trioxide is an exothermic reaction.

.....

.....

.....

..... [3]

(d) Draw an energy profile diagram to show the formation of sulfur trioxide from sulfur dioxide and oxygen.

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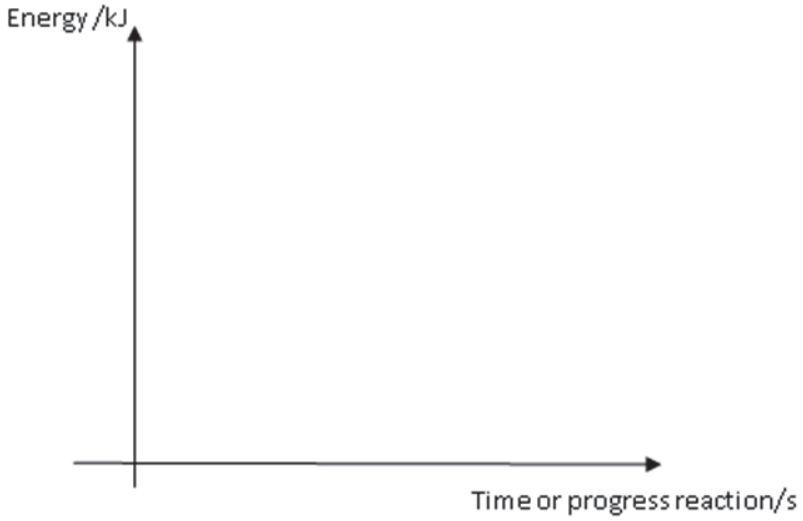
Your diagram should show and label

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



[3]

[Total: 9]

A6 The graph below shows the relationship between the concentration of carbon dioxide (in micromoles per kg of seawater) and the pH of the seawater across the years.

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Historical and Projected pH and Dissolved Carbon

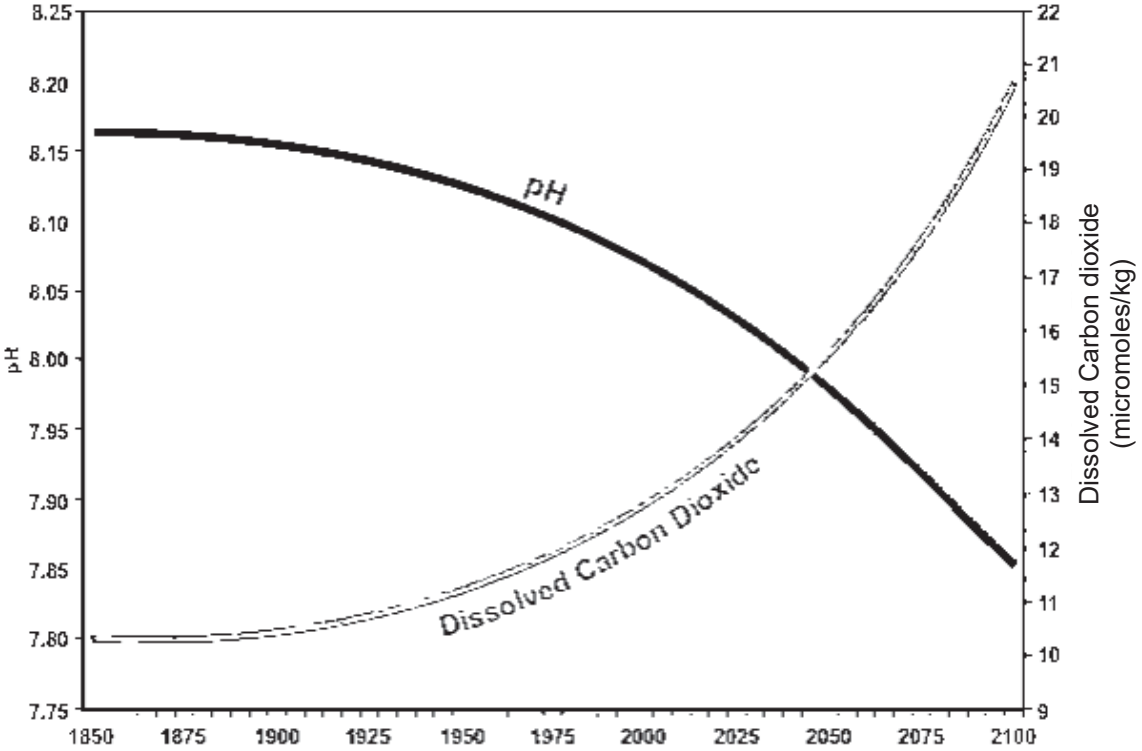

Figure 6.1

(a) **(i)** Describe how the concentration of dissolved carbon dioxide has changed across the years.

.....

.....

..... [2]

(ii) State the relationship between the concentration of carbon dioxide and the pH of the seawater across the years.

..... [1]

(b) **(i)** During the test for carbon dioxide, it is observed that white precipitate would be observed when the gas is bubbled into solution **X** initially.

Upon further bubbling of the carbon dioxide, the white precipitate would dissolve to form a colourless solution.

State the identity of solution **X**.

..... [1]

(ii) Suggest how the concentration of dissolved carbon dioxide would affect the formation of coral reefs which consist mainly of calcium carbonate.

.....

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.....

.....

..... [2]

(c) Scientists have discovered that when carbon-neutral fuels, such as ethanol, are burnt, the amount of carbon dioxide in the atmosphere remains relatively constant.

Mary stated that ethanol obtained from all forms is considered to be a form of carbon-neutral fuel. John argued that only those obtained from the fermentation of glucose can be considered as carbon-neutral.

(i) Write down the chemical equation for the fermentation of glucose.

..... [1]

(ii) Who do you agree with, Mary or John? Explain your answer.

.....

.....

.....

.....

.....

..... [4]

[Total: 11]

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Section B

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

The last question is in the form of an either/or and only one of the alternatives should be attempted.

B7 Read the information about organic acids.

Organic acids as weak acids
A weak acid is one which ionises partially to produce hydrogen ions when it is dissolved in water.

Ethanoic acid is a typical weak acid. It ionises in water to produce hydrogen ions and ethanoate ions, but the backward reaction occurs more readily than the forward one. So the ions react very easily to reform the acid.

$$CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$$

At any one time, less than 1% of the ethanoic acid molecules have converted into ions. The rest remain as simple ethanoic acid molecules.

Most organic acids are weak.

Comparing the strengths of weak acids using the acid dissociation constant, K_a
The position of equilibrium for the ionisation of each acid varies from one weak acid to another. The further to the left it lies, the weaker the acid is.

You can get a measure of the position of an equilibrium using the acid dissociation constant, K_a. The higher the value for the constant, the more the equilibrium lies to the right, the greater the extent of dissociation of the acid.

So the expression to determine the K_a of ethanoic acid is given by:

$$\frac{[H^+][CH_3COO^-]}{[CH_3COOH]},$$

where the product of the concentration of the hydrogen ion, $[H^+]$, and the concentration of the ethanoate ion, $[CH_3COO^-]$, is divided by the concentration of the undissociated ethanoic acid, $[CH_3COOH]$.

As the extent of dissociation is very little, the concentration of the undissociated acid could be taken to be the same as the concentration of the ethanoic acid before dissociation occurs.

Electronegativity of substituents
Electronegativity refers to the tendency of an atom to attract shared electrons from the covalent bond towards itself.

Atoms of halogens are generally electronegative. When a hydrogen atom in an organic acid is replaced by a halogen atom, the halogen atom draws the electron density towards itself. This reduces the electron density of the functional group, allowing the anion formed to be more stable and recombined with the hydrogen ion less readily.

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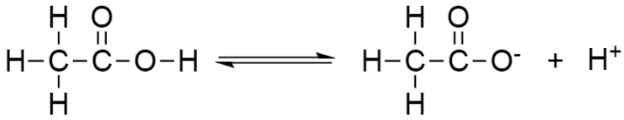
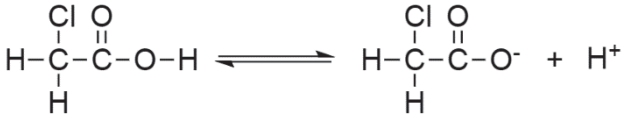
Dissociation of ethanoic acid:



Dissociation of chloroethanoic acid:



Comparing ethanoic acid and chloroethanoic acid, chloroethanoic acid will dissociate to a larger extent.

Acid dissociation constant, K_a, of different organic acids

The table below provides you with a list of K_a values of different organic acids.

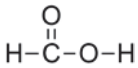
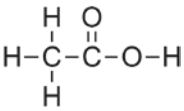
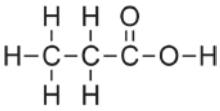
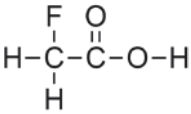
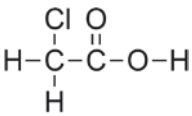
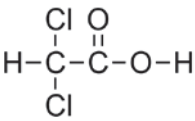
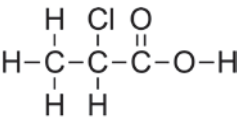
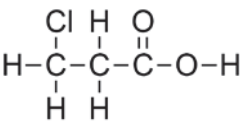
name	structure	K_a
methanoic acid		1.80×10^{-4}
ethanoic acid		1.75×10^{-5}
propanoic acid		1.34×10^{-5}
fluoroethanoic acid		2.57×10^{-3}
chloroethanoic acid		1.35×10^{-3}
dichloroethanoic acid		4.47×10^{-2}
2-chloropropanoic acid		1.48×10^{-3}
3-chloropropanoic acid		1.05×10^{-4}

Table 7.1

Adapted from:
https://www.chemguide.co.uk/physical/acidbaseeqia/acids.html
https://chem.libretexts.org/Textbook_Maps/Organic_Chemistry_Textbook_Maps/Map%3A_Organic_Chemistry_(Bruice)

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(a) Calculate the concentration of hydrogen ions, in mol/dm^3, present in 5 mol/dm^3 of ethanoic acid, with reference to Table 7.1 and the expression for K_a of ethanoic acid.

[2]

(b) Write down the expression to determine the K_a of fluoroethanoic acid.

[1]

(c) Using the information provided, describe how the number of the carbon atoms in the carboxylic acid affects the strength of the acid.

.....

.....

.....[2]

(d) Using the information provided, deduce whether fluorine or chlorine is more electronegative. Explain.

.....

.....[1]

(e) Suggest whether 2-fluoropropanoic acid or 3-fluoropropanoic acid would be a stronger acid. Explain your answer using an example.

.....

.....

.....[2]

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(f) Suggest why trichloroethanoic acid would be stronger than both chloroethanoic acid and dichloroethanoic acid. Explain in terms of electron density around the carboxylate group.

.....

.....

.....[2]

[Total: 10]

B8 **(a)** What method would you use to extract magnesium metal from its naturally occurring compound, magnesium chloride, in seawater, given that aluminium is extracted from aluminium oxide by electrolysis? Explain your answer based on the reactivity of the two metals.

.....

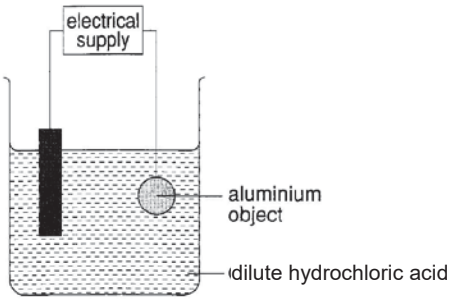
.....

.....

.....[2]

(b) Aluminium is a reactive metal and it reacts with atmospheric oxygen to form aluminium oxide, Al_2O_3. It is a metal that is widely used in various applications.

The layer of aluminium oxide can be thickened by the process known as 'anodising'. Anodising is carried out using electrolysis, in which the electrolyte is dilute hydrochloric acid. A simplified set-up is shown below.



(i) Write the ionic half equation, including state symbols, for the reaction occurring at the aluminium object, which is acting as the anode.

.....[2]

(ii) Suggest how the aluminium object is anodised during electrolysis.

.....

.....[1]

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(iii) Explain the purpose of anodising the aluminium object.

.....

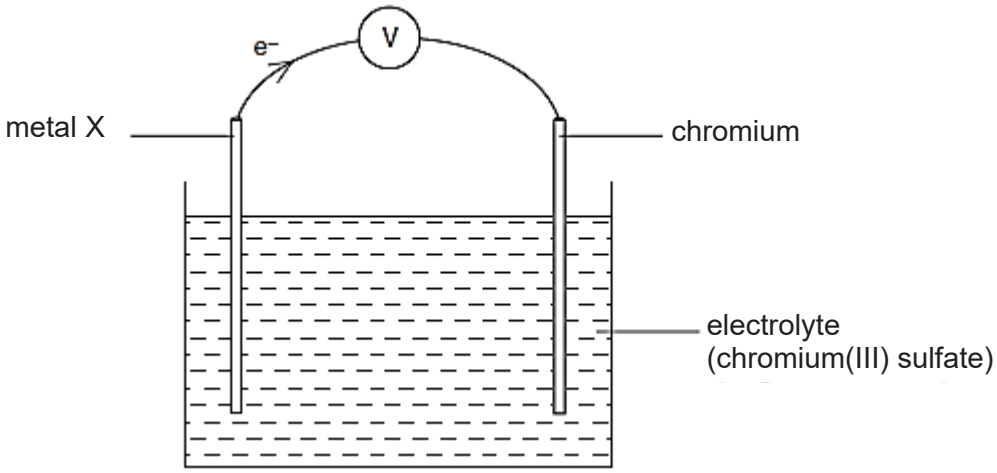
..... [1]

(iv) Aluminium is coated on an iron object to prevent the object from rusting. Explain how rusting is prevented by this method.

.....

..... [1]

(c) An electric current can also be generated by a simple electrochemical cell as shown below.



(i) Explain why the flow of electrons is in the direction shown in the diagram.

..... [1]

(ii) Chromium(III) sulfate solution is green in colour. Suggest why the colour of the chromium(III) sulfate solution fades over time.

.....

.....

..... [2]

[Total: 10]

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EITHER

B9 The general structure of an amino acid is given below:

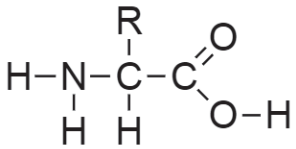

Figure 8.1

where R could just be a simple hydrogen atom or a functional group such as amino or carboxyl group.

The structure below gives a segment of a polypeptide chain with 2 amino acid residues, one with an amino group and another one with a carboxyl group for their R group, when placed in a solution with a pH of 7.

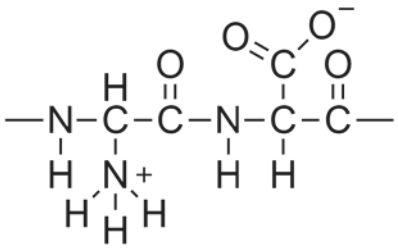

Figure 8.2

(a) Use the structures in Figures 8.1 and 8.2 to explain why

(i) an amino acid is said to be *amphoteric*; and

.....

.....

..... [2]

(ii) a polypeptide chain is said to be a *condensation polymer*.

.....

.....

..... [2]

(b) A protein molecule is formed by one or more polypeptide chains interacting and

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folding into a three-dimensional structure.

At extreme pH values, this three-dimensional structure of the protein would be altered, causing the molecule to denature and lose its function.

With reference to Figure 8.2, suggest why the shape of the molecule would be altered at different pH values.

.....

.....

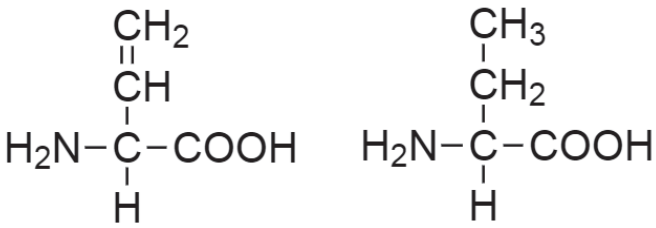
.....

..... [3]

(c) Name a synthetic polymer with similar linkage to polypeptides.

..... [1]

(d) You are given two bottles of solution, each containing a different amino acid as shown in Figure 8.3.



amino acid **J** amino acid **K**

Figure 8.3

Describe a simple chemical test to distinguish between these two amino acids, **J** and **K**.

.....

.....

..... [2]

[Total: 10]

OR

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B9 Many biological molecules are able to undergo redox reaction. An example of such a molecule would be glucose.

The Benedict's solution contains copper(II) sulfate solution and it is often used to test for the presence of a reducing sugar. If a reducing sugar is present, a brick-red precipitate would be observed in the solution.

The colour of the obtained precipitate gives an idea about the quantity of sugar present in the solution, hence the test is semi-quantitative.

(a) Explain what it means by a *redox reaction*.

.....

..... [1]

(b) Predict what would happen to the reducing sugar, in terms of transfer of hydrogen, when the reducing sugar reacts with the Benedict's solution.

Explain your prediction.

.....

.....

..... [2]

(c) Samples of solutions with varying concentrations of glucose have been reacted with Benedict's solution and the results are as given below:

Solution	Observation after reaction with Benedict's solution
P	Solution remains blue.
Q	Orange-red precipitate observed.
R	Yellow precipitate observed.
S	Blue-green precipitate observed.
T	Brick-red precipitate observed.

(i) Place the solutions **P**, **Q**, **R**, **S** and **T** in order of their concentration of glucose present, starting with the one with the highest concentration.

..... [1]

(ii) It was later discovered that solution **R** contains trace amount of impurities from fructose, another reducing sugar.

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Suggest the impact of this discovery on your answer in **(c)(i)**.

.....

.....

..... [2]

(d) A fatty acid consists of a long hydrocarbon chain attached to a carboxyl group.

Polyunsaturated fatty acids can undergo redox reaction through the addition of hydrogen.

(i) 1 mole of polyunsaturated fatty acid **Y** reacts completely with 8 g of hydrogen gas to become saturated.

Determine the molecular formula of **Y** given that each molecule has 16 carbon atoms.

[2]

(ii) Describe a simple chemical test to differentiate between **Y** and the product of the addition reaction in **(i)**.

.....

.....

..... [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	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 0
							1 H hydrogen 1										2 He helium 4
3 Li lithium 7	4 Be beryllium 9											5 B boron 11	6 C carbon 12	7 N nitrogen 14	8 O oxygen 16	9 F fluorine 19	10 Ne neon 20
11 Na sodium 23	12 Mg magnesium 24											13 Al aluminium 27	14 Si silicon 28	15 P phosphorus 31	16 S sulfur 32	17 Cl chlorine 35.5	18 Ar argon 40
19 K potassium 39	20 Ca calcium 40	21 Sc scandium 45	22 Ti titanium 48	23 V vanadium 51	24 Cr chromium 52	25 Mn manganese 55	26 Fe iron 56	27 Co cobalt 59	28 Ni nickel 59	29 Cu copper 64	30 Zn zinc 65	31 Ga gallium 70	32 Ge germanium 73	33 As arsenic 75	34 Se selenium 79	35 Br bromine 80	36 Kr krypton 84
37 Rb rubidium 85	38 Sr strontium 88	39 Y yttrium 89	40 Zr zirconium 91	41 Nb niobium 93	42 Mo molybdenum 96	43 Tc technetium -	44 Ru ruthenium 101	45 Rh rhodium 103	46 Pd palladium 106	47 Ag silver 108	48 Cd cadmium 112	49 In indium 115	50 Sn tin 119	51 Sb antimony 122	52 Te tellurium 128	53 I iodine 127	54 Xe xenon 131
55 Cs caesium 133	56 Ba barium 137	57 – 71 lanthanoids Be 137	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 Be 137	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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Answers for 4E CHEMISTRY 6092 PAPER 1 (Prelim 2018)

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

Answer Scheme for 4E Chemistry Prelim Paper 2

6092/2 – Setter: Edwin Kwek

Minus 1 mark overall for accuracy and units

A1	a) C / Si; b) N; c) K; d) Si; e) O; f) Rb; g) Fe;
A2	a) sodium chloride is giant ionic structure / has a continuous structure of ions / ions in lattice; strong electrostatics of forces between the ions so a lot of energy needed to break the strong forces; chlorine is a simple molecule / chlorine has simple covalent structure; chlorine has weak intermolecular forces between the molecules so small amount of energy required to separate the molecules; b) Ions of magnesium oxide have higher charges than those of sodium chloride; so they form stronger electrostatic forces of attraction which require larger amount of energy to overcome; c) Bromine has higher relative molecular mass than chlorine; so bromine has stronger intermolecular forces between the molecules than chlorine so more energy is required to separate the molecules;
A3	a(i) Downward trend; a(ii) The higher the first ionisation energy, the higher the reactivity of the halogen; b(i) The solution turns from colourless to reddish brown; b(ii) $Cl_2(aq) + 2Do^-(aq) \rightarrow 2Cl^-(aq) + Do_2(s)$ (balanced equation; state symbols;)
A4	a(i) $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$ a(ii) Number of moles of Zn = 1/65 = 0.015385 mol Number of moles of H_2SO_4 = 50/1000 x 1 = 0.0500 mol; Zinc is the limiting reactant Number of moles of H_2 = 0.015385 mol; Volume of H_2 = 0.015385 x 24 = 0.369 dm^3; b) Copper metal/powder/lumps. It speeds up the rate of reaction; while remains chemically unchanged at the end of the reaction; c) A catalyst provides an alternative pathway with a lower activation energy; more particles would have sufficient energy to overcome the activation energy; d) Longer. Lumps of zinc have less total surface area compared to powdered zinc; So the frequency of effective collisions decreases and speed of reaction decreases;

A5	a) When the temperature is too low, the speed of reaction is slow; When the temperature is too high, the yield of the reaction is low; b) $2SO_2 + O_2 \rightarrow 2SO_3$; c) The total energy absorbed to break bonds in 2 moles of SO_2 and 1 mole of O_2 is less than the total energy released to form bonds in 2 moles of SO_3. (energy absorbed to break bonds; energy released to form bonds; correct comparison; (minus 1 if reactants and products are not specified)) d) reaction pathway with names of products and reactants; activation energy; enthalpy change;
A6	a(i) The concentration of dissolved carbon dioxide remains fairly constant from 1850 to 1880; The concentration of dissolved carbon dioxide increases at an increasing rate after 1880; a(ii) The higher the concentration of dissolved carbon dioxide, the lower the pH; b(i) Calcium hydroxide / limewater; b(ii) Under high concentration of dissolved carbon dioxide, calcium carbonate would dissolve to form a colourless solution; This prevents calcium carbonate from accumulating to form coral reefs; c(i) $C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH$; c(ii) I agree with John. The amount of carbon dioxide absorbed by plants to make glucose during photosynthesis is equal to; the release of carbon dioxide during fermentation of glucose and combustion of ethanol; However, ethene is obtained by cracking of crude oil, a non-renewable source; So the carbon dioxide released from the burning of ethanol produced from addition of steam to ethene would increase the carbon dioxide in the atmosphere;
B7	a) $[H^+][CH_3COO^-] = 1.75 \times 10^{-5} \times 5 = 8.75 \times 10^{-5}$; $[H^+] = 0.0093541 = 0.00935$ mol/dm^3; b) $\frac{[H^+][CH_2FCOO^-]}{[CH_2FCOOH]}$; c) When the number of carbon atoms increases from methanoic acid to propanoic acid increases, K_a decreases; So the strength of the carboxylic acid decreases; d) Fluorine is more electronegative; Fluoroethanoic acid is a stronger acid / has a higher K_a than chloroethanoic acid; e) 2-fluoropropanoic acid would be a stronger acid; Comparing 2-chloropropanoic acid and 3-chloropropanoic acid, when the chlorine atom is closer to the carboxyl group as in 2-chloropropanoic acid, the K_a would be higher; f) Trichloroethanoic acid has more electronegative chlorine atoms than the other 2; so this reduces the electron density of the carboxylate group, allowing the anion formed to be more stable and recombined with the hydrogen ion less readily;

B8	a) Magnesium would be extracted by electrolysis; as magnesium is more reactive than aluminium; b(i) $4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$; b(ii) The oxygen produced during the electrolysis reacts with the aluminium metal to form a layer of aluminium oxide; b(iii) The layer acts as an impermeable layer to prevent the unreacted aluminium from reacting with other substances; b(iv) Aluminium acts as a coat around iron, preventing iron from coming into contact with water and oxygen; OR Aluminium is also more reactive than iron, so it would lose electrons more readily than iron, preventing iron from being oxidised; c(i) Metal X is more reactive than chromium; c(ii) Chromium(III) ions are discharged/reduced at the cathode (chromium metal); This causes the concentration of chromium(III) ions to decrease over time;
B9E	a(i) The amino group is able to gain hydrogen ion to act as a base; the carboxyl group is able to lose hydrogen ion to act as an acid; a(ii) It is formed when many small molecules link together to form a long-chained molecule; without the loss of a small molecule; b) At low pH, the polypeptide chain may gain hydrogen ions and become positively charged; At high pH, the polypeptide chain may lose hydrogen ions and become negatively charged; The change in the charges would affect the electrostatic interactions within the molecules; c) Nylon; d) Add aqueous bromine to a sample of each. Amino acid J will turn red-brown aqueous bromine colourless; amino acid K will not cause a change in colour in aqueous bromine;
B9O	a) It is a reaction where oxidation and reduction occur simultaneously; b) The reducing sugar would lose hydrogen atoms; Since copper(II) ions in Benedict's solution are reduced to form copper(I) ions, the reduced sugar would be oxidised; c(i) T, Q, R, S, P; c(ii) R would have a lower than expected amount of glucose present; Fructose can also reduce copper(II) ion to copper(I) ions, forming the precipitate; d(i) Number of moles of H_2 = 8/2 = 4 moles; $C_{15}H_{23}COOH$; d(ii) Add aqueous bromine to a sample of each. Y will turn red-brown aqueous bromine colourless; the product will not cause a change in colour in aqueous bromine;