Name: _____( ) Class:_____

CHIJ KATONG CONVENT
MID-YEAR EXAMINATIONS 2018
Secondary Four Express

CHEMISTRY

6092/01
Duration: 1 hour

Classes: 406

Additional Materials: Optical Answer Sheet.

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid/ tape.
Write your name, class and index number in the spaces provided at the top of this page and on the Optical Answer Sheet.

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.

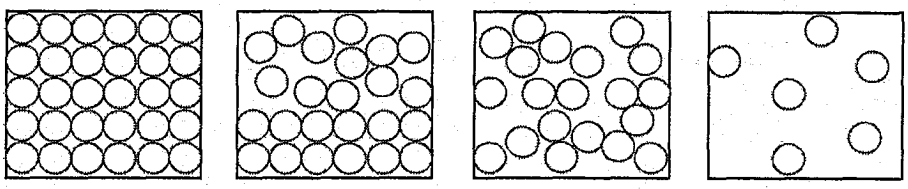
Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done on the question paper.
A copy of the Data Sheet is printed on page 14.
A copy of the Periodic Table is printed on page 15.

At the end of the examination, hand in:

1. Optical Answer Sheet; and
2. Question paper **separately**.

1 The diagram represents different arrangement of atoms.



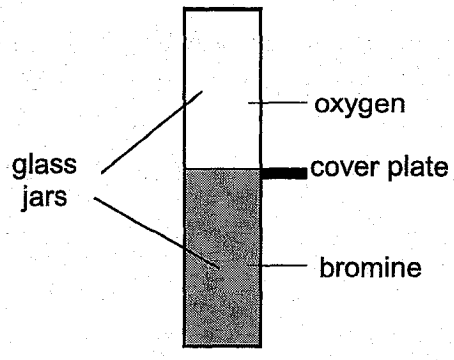
1 2 3 4

Bromine melts at -7°C and boils at 59°C. A tank filled with bromine at 30°C (room temperature) is cooled to -7°C.

Which row best represents the arrangement of bromine particles at -7°C and at 30°C?

	-7°C	30°C
A	1	4
B	2	3
C	1	2
D	2	4

2 The diagram shows the cover plate removed from the gas jars containing oxygen and bromine respectively. After several days, the colour of the gas is the same in both jars.



Which statement explains this change?

A Equal volumes of oxygen and bromine contain equal numbers of molecules.
B Oxygen and bromine gases have equal densities.
C Oxygen and bromine molecules are in random motion.
D Oxygen and bromine molecules diffuse at the same rate.

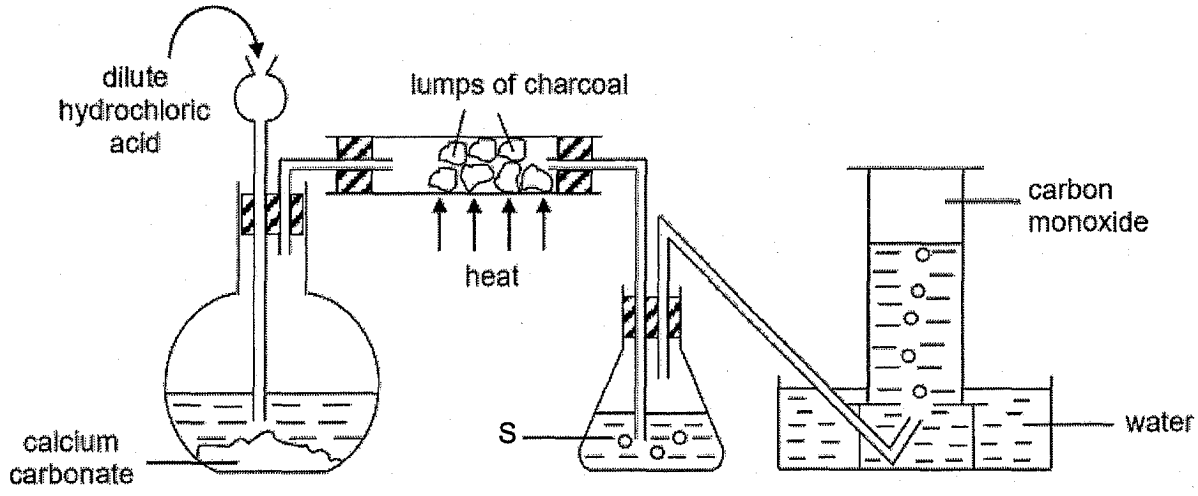
3 The properties of two substances are shown in the table.

substance	melting point/ °C	boiling point/ °C	solubility in water
1	□8	67	insoluble
2	- 95	210	soluble

Which is the best method to separate these two substances at room temperature and pressure?

A filtration
B paper chromatography
C separating funnel

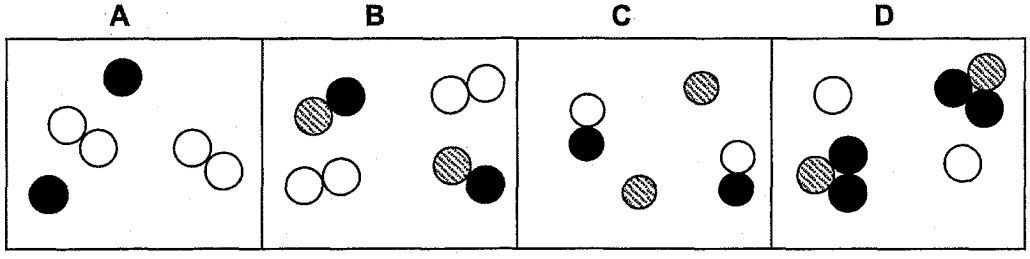
4 The diagram shows a set-up used to obtain carbon monoxide gas.



What is the purpose of solution S?

A to remove the presence of carbon dioxide gas
B to remove the presence of hydrogen chloride gas
C to remove the presence of water vapour
D to prevent water from being drawn into the hot charcoal

5 Which diagram best represents a mixture of neon and hydrogen bromide?



6 Potassium has 2 major isotopes. They are ^{39}K and ^{41}K.

If the relative atomic mass of naturally occurring potassium is 39.14, what are the relative abundance of ^{39}K and ^{41}K?

	^{39}K	^{41}K
A	7%	93%
B	25%	75%
C	75%	25%
D	93%	7%

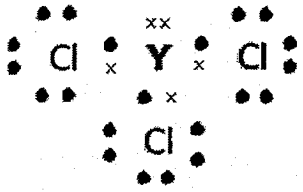
7 The table shows the number of neutrons and electrons in the following four particles.

particle	number of neutrons	number of electrons
P	18	8
Q^+	12	10
R^{2-}	16	10
S	13	11

Which particle is an isotope of P?

A Q^+
B R^{2-}
C S
D none of the above

8 The electronic structure of a compound formed between an element Y and chlorine is shown in the diagram. Only valence electrons are shown.



What is the chemical formula when sodium combines with element Y?

A Na_2Y
B NaY_2
C Na_3Y
D Na_5Y

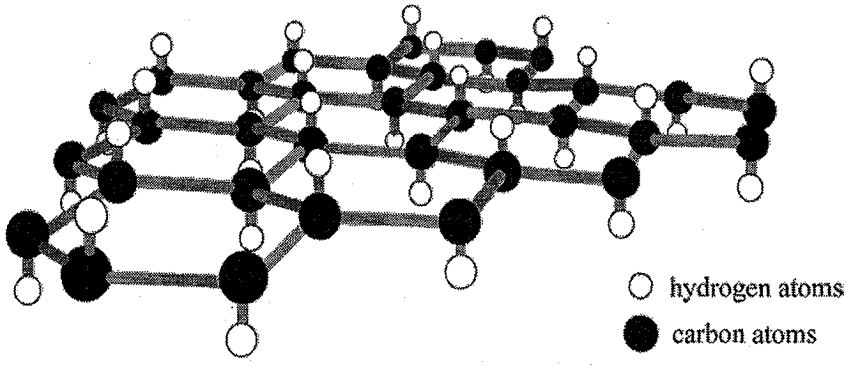
9 The following table shows four elements P, Q, R and S with their proton numbers.

elements	P	Q	R	S
proton number	6	8	17	19

Which are the likely formulae of the ionic compound and covalent compound formed from the four elements?

	ionic compound	covalent compound
A	PR_4	SR
B	S_2Q	PQ_2
C	SP	PR_4
D	SR	RQ

10 Graphane, an allotrope of carbon, has a structure similar to graphite. Graphane, however, has one hydrogen atom attached to each carbon as shown in the diagram.



Which set of properties will graphane have?

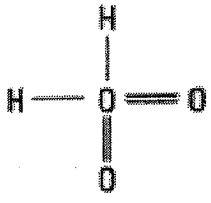
1 It is soluble in water.
2 It has a high melting point.
3 It has a giant molecular structure.
4 It conducts electricity in the solid state.

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

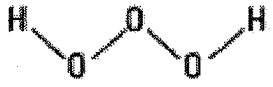
11 Trioxidane has the formula H_2O_3.

Which is the most likely structure of trioxidane?

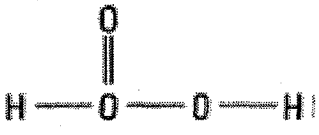
A



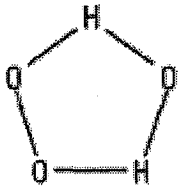
B



C



D



12 An element Q has x neutrons and y protons.

Which symbol can be used to represent the ion of Q if it belongs to Group VI?

A $^{x+y}_{y}Q^{2+}$

B $^{x}_{y}Q^{2+}$

C $^{x+y}_{y}Q^{2-}$

D $^{x}_{y}Q^{2-}$

13 The elements in a group of the Periodic Table show the following trends.

1 The element with the lowest proton number has the lowest reactivity.
2 All the elements in the group form basic oxides.
3 The density of the elements increases down the group.
4 The melting point of the elements decreases down the group.

In which group are the elements found?

A I
B IV
C VI
D VII

14 Elements X and Y are in the same period.

Which statement is correct?

A Atoms of X and Y have the same electronic structure.
B Atoms of X and Y have the same number of electrons.
C If X is a metal, Y must be a non-metal.
D The number of shells containing electrons is the same in atoms X and Y.

15 Two unlabelled bottles contain colourless solutions. One of which was sodium carbonate solution and the other was sodium chloride solution.

Which solution when added to a sample from each bottle would most readily identify the bottles?

A ammonia
B hydrochloric acid
C lead(II) nitrate
D sodium hydroxide

16 Four statements about hydroxide, OH^- ions are made.

- It reacts with hydrogen ions to form water.
- It reacts with aqueous iron(III) sulfate to form a green precipitate.
- It migrates to the cathode in electrolysis of an aqueous solution.
- Its solution gives an alkaline gas when warmed with aqueous ammonium chloride.

How many statement(s) is/ are correct?

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

17 In an experiment, 10.0 cm^3 of 0.01 mol/dm^3 copper(II) sulfate solution was mixed with 5.0 cm^3 of 0.01 mol/dm^3 sodium carbonate solution in a flask according to the equation:

$$CuSO_4 + Na_2CO_3 \rightarrow Na_2SO_4 + CuCO_3$$

What was observed in the flask at the end of the reaction?

A a colourless solution only
B a green precipitate and a blue solution
C a green precipitate and a colourless solution
D a white precipitate and a colourless solution

18 A student would like to prepare a high yield of lead(II) sulfate salt.

Which is the best method?

A Adding excess dilute sulfuric acid to lead(II) hydroxide.
B Adding excess lead(II) carbonate to dilute sulfuric acid.
C Adding excess lead metal to dilute sulfuric acid, filter and collect the residue.
D Adding excess lead metal to dilute nitric acid, filter, and followed by adding dilute sulfuric acid to filtrate.

19 The statements give some information about metals R, S, T and U.

- Carbonate of U does not decompose on heating.
- Only oxides of R and T can be reduced by heating with carbon.
- R and S react with dilute hydrochloric acid but not with cold water.
- T reacts with neither dilute hydrochloric acid nor water.

Which is the correct order of increasing reactivity of the four metals?

A T < R < S < U
B T < S < R < U
C U < S < R < T
D U < T < R < S

20 Chrysotile is a type of asbestos which is used in buildings for its flame-retarding and insulating properties. It has the formula $Mg_3Si_2O_5(OH)_4$.

What is the oxidation state of silicon in this compound?

A +2
B -2
C +4
D -4

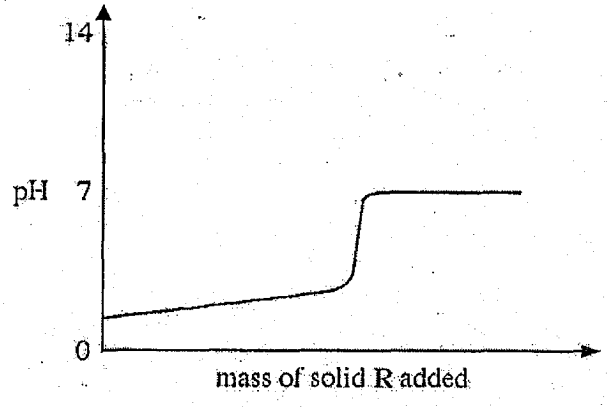
21 A sample of flue gas from the power station is bubbled into different solutions and the results are shown in the table.

solution	observation
acidified potassium manganate (VII)	purple solution turns colourless
acidified potassium iodide	colourless solution turns brown
red litmus solution	turns blue
blue litmus solution	turns red

Which are the possible gases present in the sample?

A sulfur dioxide gas and chlorine gas
B chlorine gas, hydrogen gas and carbon monoxide gas
C ammonia gas, sulfur dioxide and oxygen gas
D ammonia gas, nitrogen monoxide gas and oxygen gas

22 Solid R is gradually added to aqueous solution S. The changes in pH are shown in the graph below.



What are R and S?

	R	S
A	insoluble metal oxide	hydrochloric acid
B	insoluble non-metal oxide	sodium hydroxide
C	soluble metal oxide	hydrochloric acid
D	soluble non-metal oxide	sodium hydroxide

23 Which volume of 1.0 mol/dm^3 hydrochloric acid is required to react completely with 1.25 g of zinc carbonate?

A 10 cm^3
B 20 cm^3
C 100 cm^3
D 200 cm^3

24 An 8 g sample of oxygen atoms contains the same number of atoms as 16 g of element X.

What is X?

A helium
B sodium
C sulfur
D xenon

25 When hydrogen peroxide is used as a bleaching agent, it decomposes to form water and oxygen.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

When 68 g of hydrogen peroxide decomposes, the volume of oxygen gas collected under room temperature and pressure is 1200 cm^3.

What is the percentage purity of hydrogen peroxide?

A 2.5 %
B 5.0 %
C 10.0 %
D 15.0 %

26 The compound S_2O_7 reacts with water to produce sulfuric acid and oxygen only.

What volume of oxygen, measured at room temperature and pressure, is produced when 0.704 g of S_2O_7 is reacted?

A 48 cm^3
B 96 cm^3
C 192 cm^3
D 384 cm^3

27 Which equation does not represent a redox reaction?

A $3Cl_2(g) + 2Fe(s) \rightarrow 2FeCl_3(s)$
B $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$
C $Fe^{2+}(aq) + Mg(s) \rightarrow Fe(s) + Mg^{2+}(aq)$
D $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

28 The table shows some bond energies.

bond	kJ/ mol
C – C	346
C – H	413
Si – Si	176
Si – H	318

Which statement is correct?

A Si – Si chains are more stable than C – C chains.
B Si – Si bonds are the least readily broken of those listed.
C Methane, CH_4, is chemically more stable than silane, SiH_4.
D 346 kJ is the energy evolved when 1 mole of graphite sublimes.

29 Which is an endothermic process?

A $C(s) + O_2(g) \rightarrow CO_2(g)$
B $HCl(aq) + NaOH\ (aq) \rightarrow NaCl(aq) + H_2O(l)$
C $6CO_2(g) + 6H_2O(g) \rightarrow C_6H_{12}O_6(aq) + 6O_2(g)$
D $H_2O(g) \rightarrow H_2O(l)$

30 Which requires the largest number of electrons for complete discharge during electrolysis?

A 4 mol of aluminium ions
B 5 mol of hydroxide ions
C 6 mol of copper(II) ions
D 7 mol of oxide ions

31 The combustion of methane is an exothermic process.

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g) \qquad \Delta H = -890\ kJ/\ mol$$

How much methane should be used to produce 2670 kJ of heat?

A 48 g
B 64 g
C 96 g
D 120 g

32 Which statement correctly describes how the ammonia that is produced in the Haber Process is separated from the reaction mixture?

A By cooling the mixture.
B By dissolving the other two gases.
C By filtering out the other two gases by passing through cotton wool.
D By passing the gaseous mixture through fused calcium chloride.

33 Which statement about the three processes – respiration, combustion and rusting, is correct?

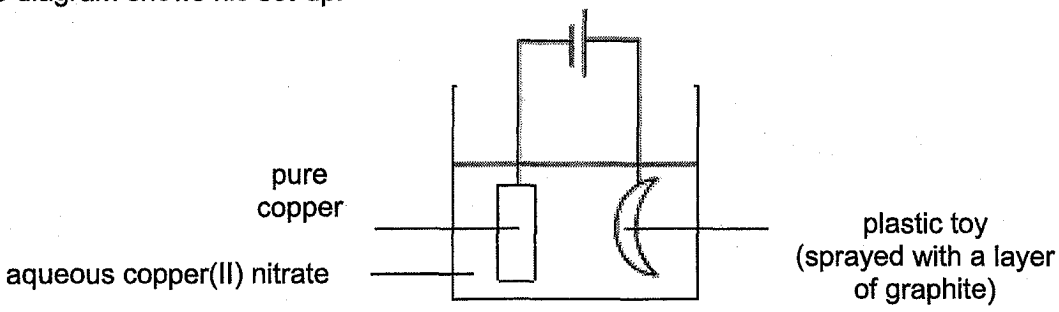
A Nitrogen must be present for the processes to occur.
B The mass of reactants is greater than that of the products.
C The processes cause a decrease in the oxygen content of the atmosphere.

34 Ammonia is manufactured by the Haber Process.

Which statement is correct?

A At the optimum conditions, the yield of ammonia is 100 %.
B Hydrogen is the reducing agent.
C Increasing the temperature lowers the activation energy.
D Nitrogen is oxidised by hydrogen.

35 A student decides to coat his plastic toy with a layer of copper metal using electrolysis. The diagram shows his set-up.

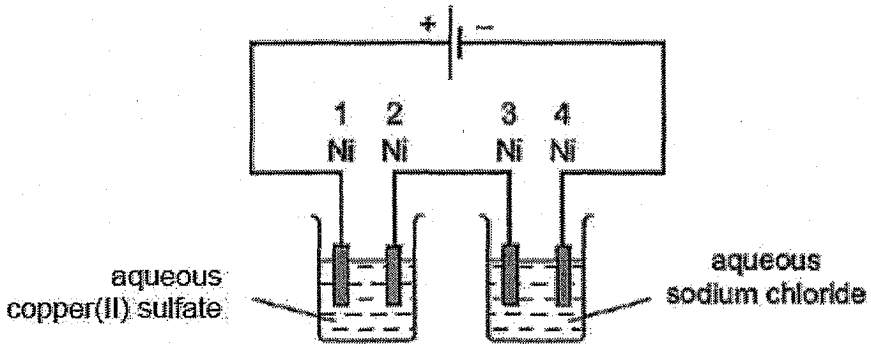


The experiment failed and no copper was deposited on the plastic toy.

Which statement best explains why the experiment failed?

A The electrolyte used should be aqueous silver nitrate.
B The plastic toy should not be submerged in the electrolyte.
C The plastic toy should not be sprayed with a layer of graphite.
D The pure copper strip should be attached to the positive electrode.

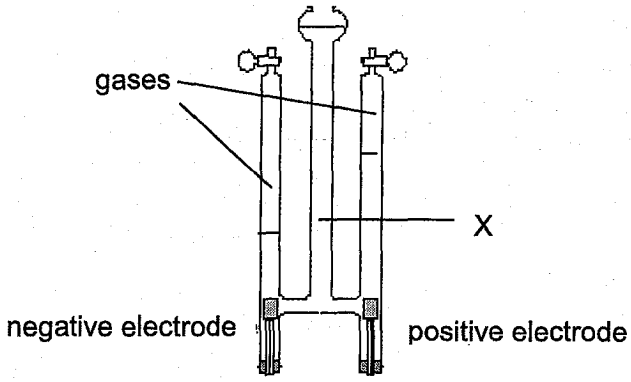
36 The diagram shows an electrolysis experiment to electroplate nickel with a different metal.



Which nickel electrode(s) is/ are plated with a metal?

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

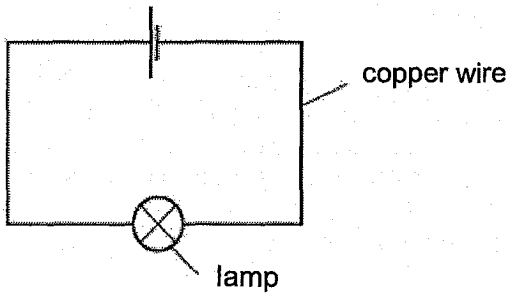
37 The diagram shows the electrolysis of a substance X after a few hours.



What substance could X be?

A copper(II) sulfate solution
B concentrated hydrochloric acid
C silver nitrate solution
D sodium chloride solution

38 Copper wire is used to complete an electrical circuit.

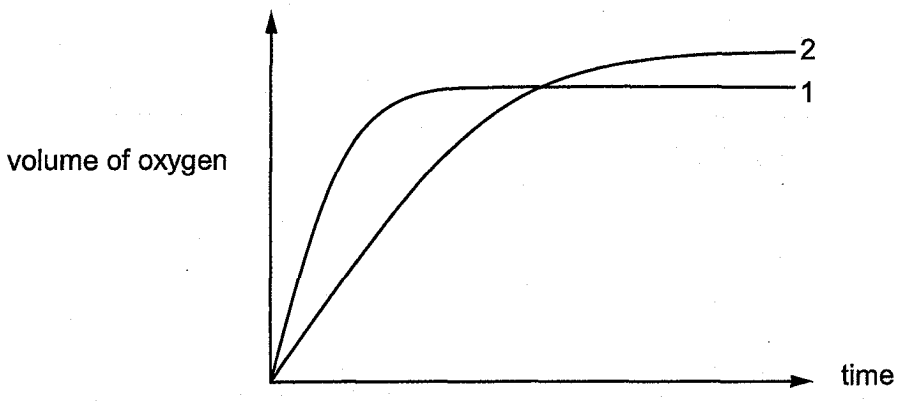


Which statement correctly describes what happens in the copper wire?

A Electrons move along the wire to the negative terminal and positive ions stay in position.
B Electrons move along the wire to the positive terminal and positive ions move to the negative terminal.
C Electrons move along the wire to the positive terminal and positive ions stay in position.
D Negative ions move along the wire to the positive terminal while positive ions move to the negative terminal.

39 In the graph, curve 1 was obtained by observing the decomposition of 100 cm^3 of 1.0 mol/dm^3 hydrogen peroxide solution, catalysed by manganese(IV) oxide.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$



Which alteration to the original experimental conditions would produce curve 2?

A adding some 0.1 mol/dm^3 hydrogen peroxide solution
B lowering the temperature
C using a different catalyst
D using less manganese(IV) oxide

40 In which reaction is the pressure least likely to affect the speed of reaction?

A $C(s) + CO_2(g) \rightarrow 2CO(g)$
B $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
C $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$
D $NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$

Colours of Some Common Metal Hydroxides

aluminium hydroxide	white
calcium hydroxide	white
copper(II) hydroxide	light blue
iron(II) hydroxide	green
iron(III) hydroxide	red-brown
lead(II) hydroxide	white
zinc hydroxide	white

The Periodic Table of Elements

Group																	
	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
	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
	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
	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
	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
	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 –
	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 –		

Key

proton (atomic) number
atomic symbol
name
relative atomic mass

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 –

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

Name: _____( ) Class: _____

CHIJ KATONG CONVENT
MID-YEAR EXAMINATIONS 2018
Secondary Four Express

CHEMISTRY

6092/02
Duration: 1 hour 45 minutes

Class: 406

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your name, registration number and class on all the work you hand in.
You may use a soft pencil for any diagrams, graphs, tables or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid/ tape.
The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.
Write your answers in the spaces provided on the Question Paper.

Section B
Answer **all** three questions, the last question is in the format of either/ or.
Write your answers in the spaces provided on the Question Paper.

You are advised to spend no longer than one hour on Section A and no longer than 45 minutes on Section B.
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 Data Sheet is printed on page 21.
A copy of the Periodic Table is printed on page 22.

FOR EXAMINER'S USE	
Paper 1	/ 40
Section A	/ 50
Section B	/ 30

Section A [50 marks]

Answer **all** the questions in this section.
Write your answers in the spaces provided.

1 Fig 1.1 shows the set-up of an experiment. After some time, a ring of yellow powder is seen in the tube. A, B or C are possible positions at which this ring may be formed.

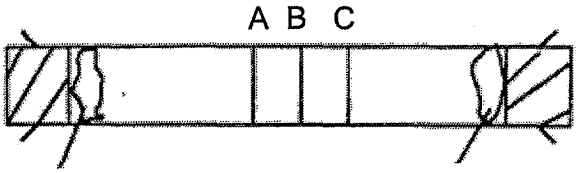


Fig 1.1

It is known that hydrogen sulfide gas reacts with sulfur dioxide gas as follows:

$$2H_2S(g) + SO_2(g) \rightarrow 3S(s) + 2H_2O(g)$$

(a) Name the yellow powder formed in the tube.

..... [1]

(b) (i) At which position, A, B or C is the ring of yellow powder most likely to be formed?

..... [1]

(ii) Explain your answer to **(b)(i)**.

.....

.....

..... [2]

[Total: 4]

2 Fig. 2.1 shows the structures of various compounds, **A**, **B**, **C**, **D**, **E** and **F**.

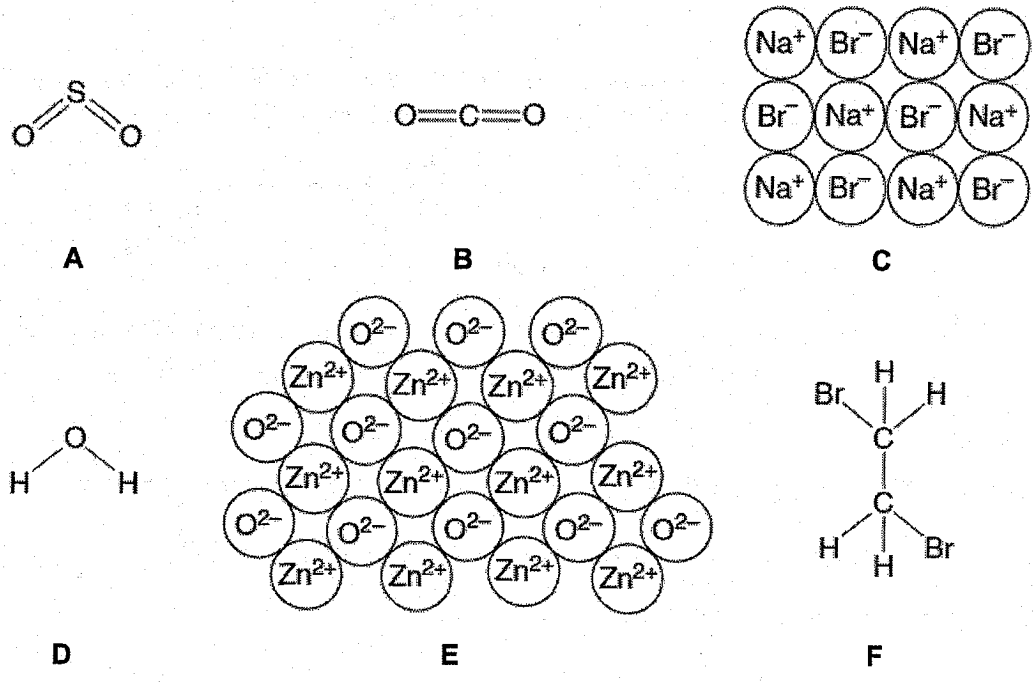


Fig. 2.1

(a) Use the letters **A** to **F** to answer the following.
Each compound may be used once, more than once or not at all.

(i) Which compound is most likely to contribute to acid rain?

..... [1]

(ii) Which compound is an amphoteric oxide?

..... [1]

(iii) Which two of these compounds have giant structures?

..... [1]

(iv) Which compound when molten, releases a reddish brown gas at the anode during electrolysis?

..... [1]

(b) State the empirical formula of compound **F**.

..... [1]

[Total: 5]

3 Two experiments were carried out to find out the positions of the metals cobalt (Co), gallium (Ga) and bismuth (Bi) in the reactivity series.

In experiment I, hydrogen gas was passed separately over the heated oxides of the three metals in the combustion tube. The results are given in Table 3.1.

Table 3.1

metal oxide	formula	appearance before heating	appearance after heating
cobalt oxide	CoO	green powder	grey powder and a colourless liquid on the side of the glass tube
gallium oxide	Ga_2O_3	white powder	white powder; no liquid on glass tube
bismuth oxide	Bi_2O_3	yellow powder	grey powder and a colourless liquid on the side of the glass tube

In experiment II, pieces of Bi, Ga and Co were added separately to a solution of $Pb(NO_3)_2$. The results are given in Table 3.2.

Table 3.2

cobalt	gallium	bismuth
Grey solid formed on cobalt. The solution slowly turned pink.	Grey solid formed on gallium. The solution remained colourless.	No change in bismuth metal or in solution.

(a) From the results of both experiments, place Bi, Ga, Co and Pb in the correct order in the reactivity series.

most reactive .....

.....

.....

least reactive .....

[2]

(b) Name the colourless liquid observed when Bi_2O_3 and CoO are heated in hydrogen.

..... [1]

(c) State the property hydrogen shows when it reacts with bismuth oxide.

..... [1]

(d) Write an ionic equation for the reaction between Ga and $Pb(NO_3)_2$ solution.

3 **(e)** Describe what you would observe if a piece of cobalt is placed in aqueous bismuth nitrate.

.....

..... [2]

[Total: 8]

4 Fig. 4.1 shows some reactions of copper(II) nitrate, $Cu(NO_3)_2$.

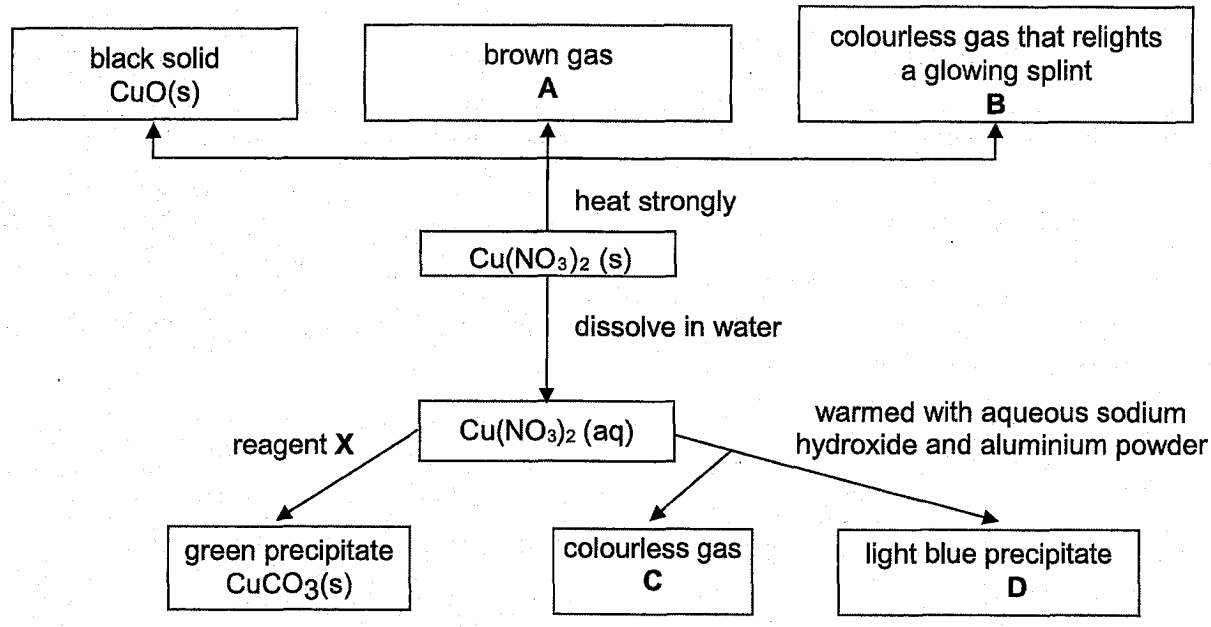


Fig. 4.1

(a) When two moles of $Cu(NO_3)_2$ is heated strongly, two moles of CuO, four moles of **A** and one mole of **B** are made.

(i) Identify **B**.

..... [1]

(ii) Write the balanced chemical equation for the reaction when $Cu(NO_3)_2$ is heated.

..... [2]

(b) Identify

C ..... [1]

D ..... [1]

X ..... [1]

(c) Write the ionic equation for the formation of the light blue precipitate **D**.

[1]

5 5 g of hydrogen reacts with 142 g of chlorine to form hydrogen chloride. The reaction is exothermic and can be represented by the equation shown.

$$H_2 + Cl_2 \rightarrow 2HCl \qquad \Delta H = -184 \text{ kJ/mol}$$

(a) Explain with supporting calculations which reactant is in excess.

.....

.....

.....

..... [3]

(b) Calculate the energy released when 4 g of hydrogen reacts completely with 71 g of chlorine.

You may assume that no other side reaction occurs.

..... [1]

(c) Explain why the reaction is exothermic, in terms of the energy changes that take place during bond breaking and bond making.

.....

.....

.....

..... [3]

[Total: 7]

6 In an experiment, 20.0 cm^3 of 0.550 mol/dm^3 of barium nitrate was added to excess aqueous sodium sulfate to produce barium sulfate and sodium nitrate.

(a) Calculate the maximum mass of barium sulfate produced.

mass = ... g

[2]

(b) A mass of 1.92 g of dry barium sulfate was obtained.

Calculate the percentage yield of barium sulfate.

percentage yield = ... %

[2]

[Total: 4]

7 Fig. 7.1 shows part of the electrolytic cell for an electroplating process.

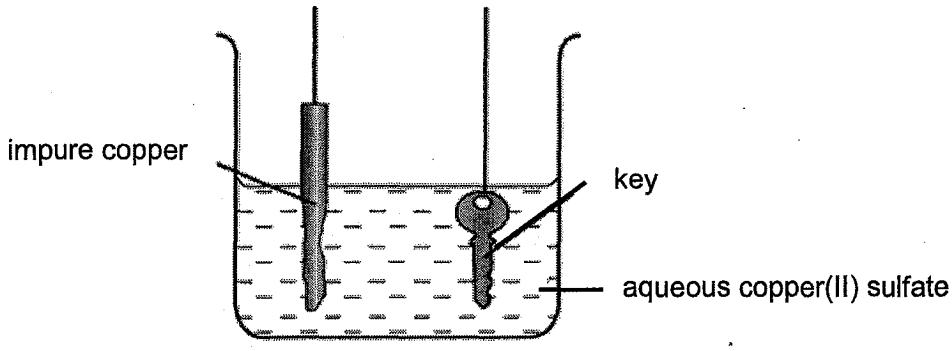


Fig. 7.1

(a) A student wants to electroplate her key with copper.

Complete Fig. 7.1 by drawing in a battery and connecting wires. [1]

(b) Write the half equations for the reactions occurring at the electrodes.

anode : .....

cathode : ..... [2]

(c) State one use of electroplating.

..... [1]

(d) Table 7.1 shows information about the electroplating process.

Table 7.1

	before electroplating	after electroplating
mass of impure copper electrode/ g	150	136.5
mass of key/ g	62	74.6

Calculate the percentage of impurities in the impure copper electrode

percentage yield = ... %

[Total: 6]

8 **(a)** Fig. 8.1 shows the set-up of a simple cell which can be used to determine the relative positions of metals in the reactivity series. The voltage of the cell is measured by a voltmeter.

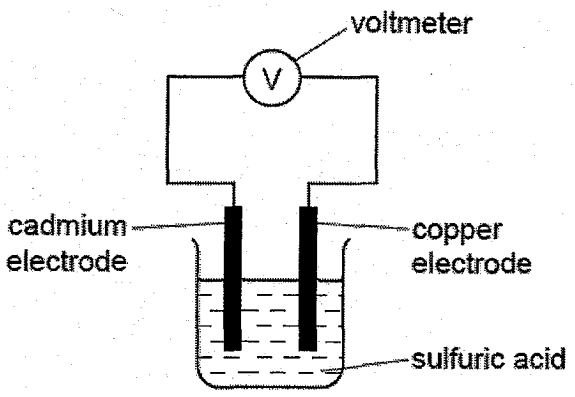


Fig. 8.1

Results from cells using the metals cadmium, tin, zinc and copper are given in Table 8.1.

Table 8.1

cell	electrode 1 (–)	electrode 2 (+)	voltage / volts
1	cadmium	copper	0.74
2	tin	copper	0.48
3	zinc	copper	1.10

(i) Explain what is meant by a *simple cell*?

.....

..... [2]

(a) (ii) Place the four metals in order of increasing reactivity and explain how you used the data in Table 8.1 to arrive at this order.

least reactive .....

.....

.....

most reactive .....

.....

.....

.....

..... [3]

8 **(b)** Cadmium is in the same group of the Periodic Table as zinc. Cadmium carbonate is insoluble in water and reacts in the same way as zinc carbonate with dilute acids. Cadmium sulfate is soluble in water.

Describe how you would prepare a pure, dry sample of cadmium carbonate, starting from cadmium sulfate.

.....

.....

.....

.....

.....

.....

..... [4]

[Total: 9]

Section B [30 marks]

Answer **three** questions.

Question **11** is in the form of an **Either/ Or** question. Only one part should be answered.

Write your answers in the spaces provided.

9 Aspirin is a medicine that is used as a painkiller. It is made from salicylic acid.

(a) A student makes a sample of aspirin. She thinks it contains some impurities.

(i) The student tests the melting point of the sample of aspirin.

Explain how she can use the result of the test to find out whether the sample contains impurities.

.....

.....

..... [2]

(ii) The student uses chromatography to compare the sample of aspirin in **(a)** with pure samples of aspirin and salicylic acid.

Fig. 9.1 shows the results of the chromatogram.

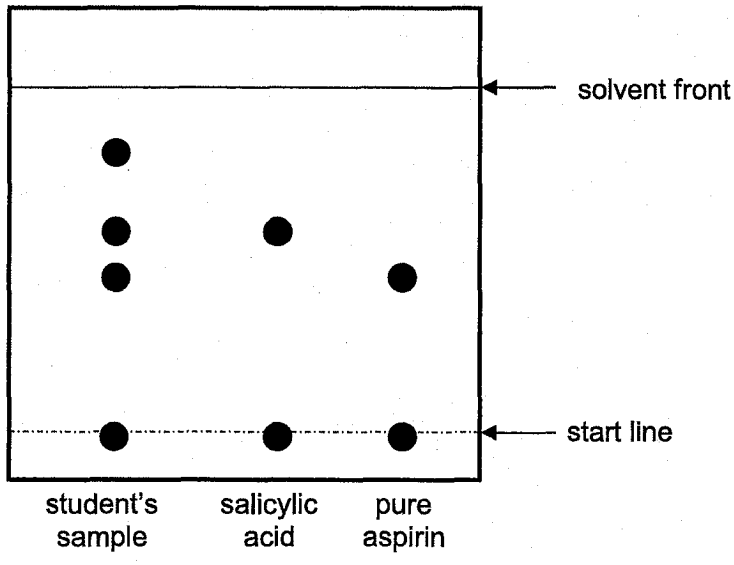


Fig. 9.1

Is the student's sample of aspirin pure? Explain your answer.

.....

..... [2]

9 (a) (iii) In another chromatography using pure samples of aspirin and salicylic acid, the solvent was allowed to travel 9 cm from the start line.

Table 9.1 shows the Rf values of pure aspirin and salicylic acid.

Table 9.1

substance	aspirin	salicylic acid
R_f values	0.56	0.654

Using the information provided in Table 9.1, calculate the distance travelled by aspirin.

distance = ... cm
[1]

(b) The student buys a few packets of aspirin tablets from a store and performs a titration using a crushed tablet and aqueous sodium hydroxide.

The formula for aspirin can be represented as  .

The equation for the reaction between aspirin and aqueous sodium hydroxide is shown below.

Table 9.2 shows the results of the student's titration.

Table 9.2

concentration of aqueous NaOH used	0.10 mol/dm^3
volume of aqueous NaOH needed for neutralisation	15.90 cm^3
relative molecular mass of aspirin	180

(i) Calculate the mass of aspirin, in mg, in one tablet. Leave your answer in 3 significant figures. (1 g = 1000 mg)

mass = ... g

9 (b) (ii) It is known that some aspirin tablets also contain citric acid. The student repeats the titration using one of these tablets.

Explain why the mass of aspirin calculated in the second titration is different from that in **(b)(i)**.

.....

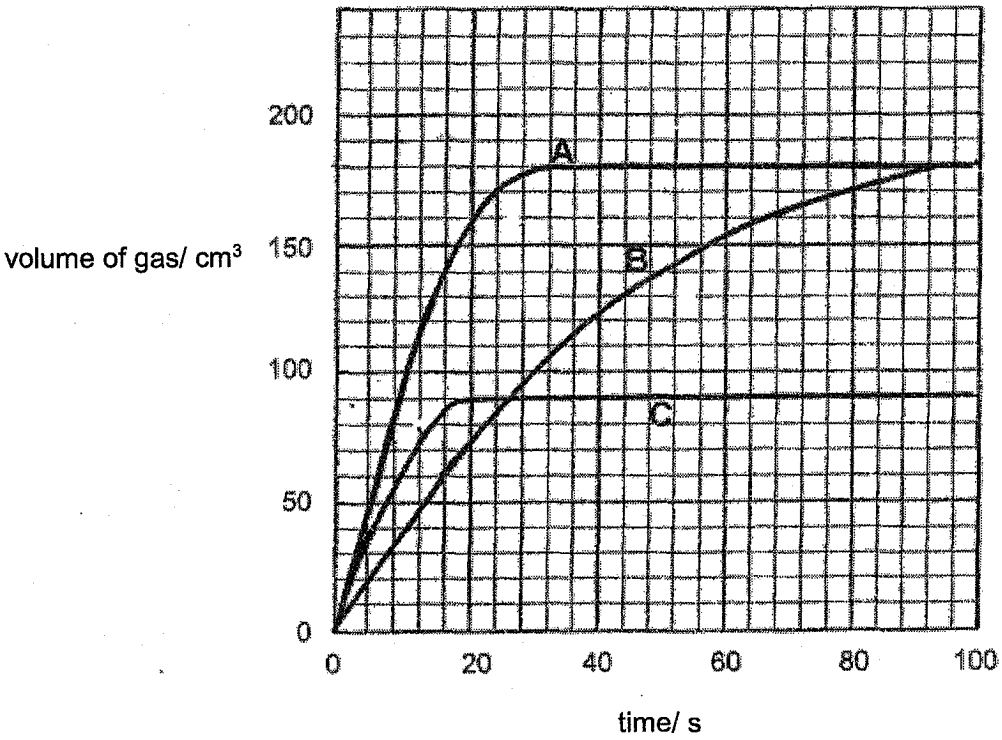
.....

..... [2]

[Total: 10]

10 An experiment was carried out involving two separate reactions between 0.18 g of magnesium and two acids, hydrochloric acid and sulfuric acid. The volume and concentration of both acids used were 20.0 cm^3 and 2.00 mol/dm^3. The results of reactions A and B are shown on Fig. 10.1.

A third reaction C was carried out using 20.0 cm^3 and 2.00 mol/dm^3 of an acid and a unknown amount of magnesium ribbon.



(a) With relevant equations and calculations, explain why the same volume of gas was produced for reactions A and B.

.....

.....

.....

.....

.....

..... [3]

10 **(b)** Determine which reaction, A or B, used sulfuric acid.

Explain your choice.

.....

.....

.....

.....

.....

..... [3]

(c) In reaction C, identify the acid and calculate the mass of magnesium ribbon that was used.

.....

.....

.....

..... [2]

(d) When calcium was used in place of magnesium to react with the 2.00 mol/dm^3 sulfuric acid, the reaction stopped very quickly and also produced less gas.

Give reasons for this observation.

.....

.....

.....

..... [2]

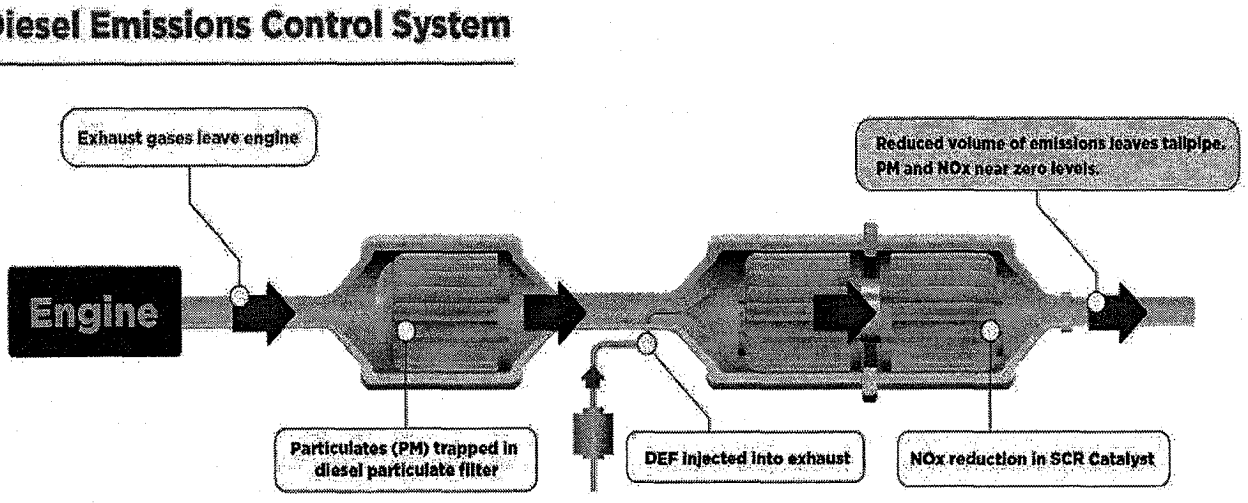
[Total: 10]

11 Either

Diesel engines can be run with a lean burn air-to-fuel ratio which is larger than that in petrol engine, This is to ensure the full combustion of soot and to prevent them from giving out unburnt fuel. This then leads to generation of oxides of nitrogen (NO_x), which are harmful pollutants, from the nitrogen and oxygen in the air.

Introduction to Diesel Exhaust Fluid (DEF)
Diesel exhaust fluid (DEF) is an aqueous urea solution made with 32.5% by mass of urea, $(NH_2)_2CO$, and 67.5% by mass of deionised water. It is called AUS 32 (aqueous urea solution).

DEF is used in selective catalytic reduction (SCR) in order to lower the concentration of NO_x in the diesel exhaust emissions from diesel engines. Within the SCR catalyst, the NO_x are catalytically reduced by ammonia into water and nitrogen, which are both harmless. These are then released through the exhaust.



Source: http://www.dieselforum.org/about-clean-diesel/what-is-scr

Selective Catalytic Reduction (SCR) systems
SCR catalysts are made from various ceramic materials used as a carrier, such as titanium oxide, and active catalytic components are usually oxides of base metals such as vanadium, molybdenum and tungsten.

The two most common designs of SCR catalyst geometry used today are honeycomb and plate. Each design has different advantages and disadvantages.

	plate-type	honeycomb-type
pressure drop	lower	larger
plugging and fouling	less susceptible	more susceptible
size	large and bulky	smaller
price	expensive	relatively cheaper

**'Plugging and fouling' causes the catalyst to be coated with a layer of unwanted material.*

Reduction of oxides of nitrogen (NO_x)

DEF from a separate tank is injected into the exhaust pipeline. When it is injected into the hot exhaust gas stream, the water evaporates and the urea thermally decomposes to form ammonia and isocyanic acid:

$$(NH_2)_2CO(g) \rightarrow NH_3(g) + HNCO(g)$$

The isocyanic acid hydrolyses to carbon dioxide and ammonia:

$$HNCO(g) + H_2O(g) \rightarrow CO_2(g) + NH_3(g)$$

Overall reaction:

$$(NH_2)_2CO(g) + H_2O(g) \rightarrow 2NH_3(g) + CO_2(g)$$

From this point, ammonia, in the presence of oxygen and a catalyst, will reduce oxides of nitrogen:

$$2NO(g) + 2NH_3(g) + \frac{1}{2}O_2(g) \rightarrow 2N_2(g) + 3H_2O(g) \text{ and}$$

$$3NO_2(g) + 4NH_3(g) \rightarrow \frac{7}{2}N_2(g) + 6H_2O(g)$$

The overall reduction of nitrogen monoxide by urea is:

$$2(NH_2)_2CO(g) + 4NO(g) + O_2(g) \rightarrow 4N_2(g) + 4H_2O(g) + 2CO_2(g)$$

DEF is injected into the exhaust gas at 2–6% of diesel consumption volume.

Storage

It is recommended that DEF be stored in a cool, dry, and well-ventilated area that is out of direct sunlight.

Adapted from: https://en.wikipedia.org/wiki/Diesel_exhaust_fluid
https://en.wikipedia.org/wiki/Selective_catalytic_reduction

(a) Suggest why the running of diesel engines with a lean burn air-to-fuel ratio leads to the production of more oxides of nitrogen.

.....

..... [1]

(b) Suggest why, unlike diesel engines, petrol engines do not require the use of DEF.

.....

..... [1]

(c) Which type of SCR design, honeycomb or plate, is more suitable to be fitted in cars?

Give a reason for your answer.

.....

11 **(d)** State the overall equation for the reduction of nitrogen dioxide (NO_2) by urea.

..... [1]

(e) **(i)** What is the maximum volume of DEF vapour that needs to be added to 100 dm^3 of diesel vapour?

..... [1]

(ii) What is the maximum volume of nitrogen gas that can be formed from the combustion of 100 dm^3 of diesel vapour if the DEF injected only contains urea?

..... [1]

(f) State why active catalytic components are usually oxides of metals such as vanadium, molybdenum and tungsten instead of Group I metals.

.....

..... [1]

(g) Suggest why DEF should be stored in a cool area that is out of direct sunlight.

.....

..... [1]

(h) Explain why the use of DEF is not completely environmentally friendly.

.....

.....

..... [2]

[Total: 10]

11 OR

The reaction between nitrogen and hydrogen to form ammonia is a reversible reaction. This means that when nitrogen and hydrogen react to form ammonia, some ammonia is decomposed back to its reactants at the same time. The two reactions are shown below:

Forward reaction: $N_2 + 3H_2 \rightarrow 2NH_3$ $\triangle H = -92.4$ kJ/mol
Backward reaction: $2NH_3 \rightarrow N_2 + 3H_2$

The forward reaction is exothermic.
During the development of Haber process, Fritz Haber conducted a series of experiments to determine the most cost-effective way to produce ammonia. Table 11.1 shows some of the results. In each case, the experiment began with the molar ratio of nitrogen to hydrogen 1:3.

Table 1.1

temperature (°C)	pressure (atm)		
	300	400	500
400	48% NH_3	55% NH_3	61% NH_3
500	26% NH_3	32% NH_3	38% NH_3
600	13% NH_3	17% NH_3	21% NH_3

He applied **Le Chatelier's principle** to the reaction. This principle, in simple terms, states that when a change is applied to a reaction system, the system will tend to move in a direction that reduces the change.

For example, when a change such as increased pressure is applied to a mixture of nitrogen and hydrogen, more ammonia will be formed as there will be fewer number of moles of ammonia than nitrogen and hydrogen. As a result, the change is reduced. Hence, in this reaction, an increase in pressure tends to favour the forward reaction as it reduces the pressure on the system. Consequently, more ammonia is produced.

(a) By referring to the data in Table 11.1, state the physical conditions required to produce the highest amount of ammonia.

.....

..... [1]

(b) With reference to the kinetic particle theory and relevant number of moles of gases, explain why the forward reaction of Haber Process reduces pressure.

.....

.....

.....

..... [2]

11 **(c)** Ideally, as ammonia is being formed, it should be removed as quickly as possible.
With reference to Le Chatelier's principle and/ or other suitable explanation, suggest why this is done.

.....

.....

.....

..... [2]

(d) With reference to Le Chatelier's principle and enthalpy change, explain the effect of raising the temperature on the amount of ammonia produced in the Haber process.

.....

.....

.....

..... [2]

(e) One way to increase the rate of reaction between nitrogen and hydrogen to produce ammonia is to raise the temperature. Unfortunately, this method increases the rate of decomposition of ammonia as well.

Suggest another way to increase the rate of reaction between nitrogen and hydrogen in the Haber process without altering the temperature.

..... [1]

(f) Draw and label the energy profile diagram of the forward reaction of the Haber process.

[2]

Colours of Some Common Metal Hydroxides

aluminium hydroxide	white
calcium hydroxide	white
copper(II) hydroxide	light blue
iron(II) hydroxide	green
iron(III) hydroxide	red-brown
lead(II) hydroxide	white
zinc hydroxide	white

The Periodic Table of Elements

Group																	
	II											III	IV	V	VI	VII	0
							1 H hydrogen 1										2 He helium 4
	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
	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
	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
	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
	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 –
	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 –

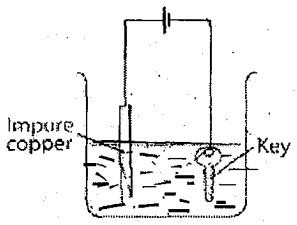
olume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.).

4E Chemistry MYE 2018 answer scheme

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

Section A (50 marks)

Qn no	Answer	Marks/ Remarks
1(a)	sulfur	[1]
1(b)(i)	Position **C**	[1]
1(b(ii)	Hydrogen sulfide (Mr = 34) has a smaller molecular mass compared to sulfur dioxide (Mr = 64). Hence, hydrogen sulfide diffuses faster than sulfur dioxide and travel further to react with sulfur dioxide at point **C**.	[1] [1]
2(a)(i)	A	[1]
2(a)(ii)	E	[1]
2(a)(iii)	C and E	[1]
2(a)(iv)	C	[1]
2(b)	CH_2Br	[1]
3(a)	Gallium/ Ga Cobalt/ Co Lead/ Pb Bismuth/ Bi	All correct – [2], 2-3 correct – [1]
3(b)	water	[1]
3(c)	Hydrogen is a reducing agent. (Accept Hydrogen is more reactive than Bismuth)	[1]
3(d)	$2Ga\ (s) + 3Pb^{2+}\ (aq) \rightarrow 2Ga^{3+}\ (aq) + 3Pb\ (s)$ ½ mark – correct formula ½ mark – correct state symbols 1 mark – correct balancing	[2]
3(e)	Grey solid formed on cobalt. The solution turned pink.	[1] [1]
4(a)(i)	B is O_2	[1]
4(a)(ii)	$2Cu(NO_3)_2 \rightarrow 2CuO + 4NO_2 + O_2$ Identification of NO_2 as a product (1) Balanced equation	[2]
4(b)	C is ammonia	[1]
	carbonate	
4(c)	$Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$	[1]

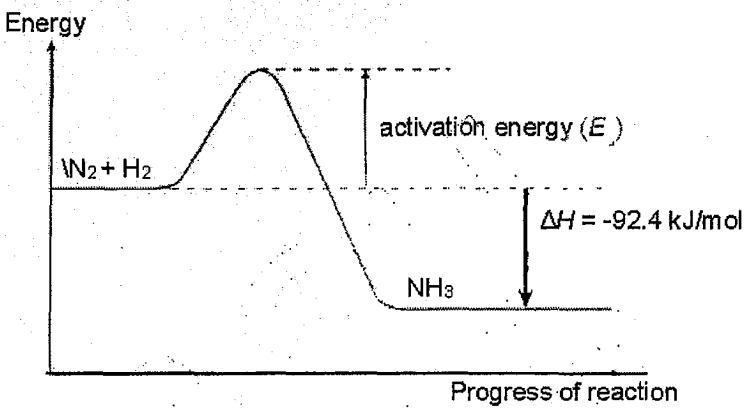
5(a)	Hydrogen; Number of moles of H_2 = 5/2 = 2.5 mol Number of moles of Cl_2 =142/71 = 2 mol; Mole ratio is 1: 1, hence hydrogen is in excess	[1] [1] [1]
5(b)	Energy released = 184 x 2 = 368 kJ;	[1]
5(c)	Energy taken in to break bonds in hydrogen and chlorine; is less than; energy given out to form bonds in hydrogen chloride;	[1] [1] [1]
6(a)	Number of moles = 0.020 X 0.550 = 0.011 mol Mass = 0.011 x (137 + 32 +16x4) = 2.563 g	[1] [1]
6(b)	Percentage yield = (1.92 ÷ 2.563) x 100 % = 74.9% ECF for (a)	[1]
7(a)	 Must show correct polarity of cell	[1]
7(b)	Anode: $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$ Cathode: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ *1 mark for each correctly balanced equation with state symbols.*	[1] [1]
7(c)	To prevent corrosion/ to improve the appearance of an object	[1]
7(d)	Mass of copper + impurities lost from electrode = 150 - 136.5 =13.5 g Mass of copper deposited on key = 74.6 - 62 =12.6 g Mass of impurity = 13.5 - 12.6 =0.9 g Percentage of impurities in copper electrode $= \frac{0.9}{13.5} \times 100\% = 6.67\%$ *Award 1 mark if students found percentage purity instead of percentage impurity.*	 0.5 0.5 0.5 0.5
8(a)(i)	device which changes chemical energy [1] into electrical energy; [1] OR OR	

8(a)(ii)	Cu Sn Cd Zn (i.e. all 4 in correct order) The further apart the metals in the reactivity series, the greater the voltage produced. Tin-copper pair has the smallest voltage hence tin is just slightly more reactive than copper. Zinc-copper pair has the largest voltage hence zinc is the most reactive amongst the 4 metals.	[1] [1] [1]
8(b)	1. Add aqueous cadmium sulfate to aqueous sodium carbonate (or any soluble carbonate). 2. Filter the mixture to obtain the precipitate (cadmium carbonate). 3. Wash the residue. 4. Dry the residue (using sheets of filter paper).	[1] [1] [1] [1]

Section B (30 marks)

Qn no	Answer	Marks/ Remarks
9(a)(i)	If his sample is pure, the melting point should be a fixed temperature. If his sample is not pure, the aspirin should melt over a range of temperatures.	[1] [1]
9(a)(ii)	Sample is not pure. Sample contains **two** impurities. The impurities are salicylic acid and an unidentified/unknown substance.	 [1] [1]
9(a)(iii)	$0.56 \times 9 = 5.04$ cm	[1]
9(b)(i)	mole ratio of aspirin : NaOH = 1:1 (from equation) Mass of aspirin = $\left(\frac{15.90}{1000} \times 0.10\right) \times \frac{1}{1} \times 180 = 0.286$ g = **286 mg** *Award 1m for calculating number of moles of aspirin using 'M = C × V'.* *Award 1m for calculating mass of aspirin using 'mass = molar mass × moles'.* *Award 1m for giving final answer in mg and 3 s.f.*	[3]
9(b)(ii)	Citric acid (in the tablets) will also **react with / be neutralised** by sodium hydroxide during the titration. Hence **more** sodium hydroxide would be used / the calculated mass of aspirin will be **greater** than actual.	[1] [1]
10(a)	No. of moles of Mg = 0.18 / 24 = **0.0075** No. of moles of hydrochloric acid = No. of moles of sulfuric acid = 0.02 x 2.00 = **0.04** **$Mg + 2\ HCl \rightarrow MgCl_2 + H_2$** 1 mole of Mg reacts with 2 moles of HCl, hence, magnesium is the limiting reactant and hydrochloric acid is in excess. **$Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$** 1 mole of Mg reacts with 1 mole of H_2SO_4 hence, magnesium is the limiting reactant and sulfuric acid is in excess. Since magnesium is the **limiting reactant for both reactions**, the same volume of hydrogen is produced.	 [1] [1] [1]
10(b)	Curve A hydrochloric acid because there are **more hydrogen ions per unit volume /**	[1]

10(c)	The acid used is **sulfuric acid** because it has the same initial rate of reaction. Volume of hydrogen = 90 cm^3. No. of moles of hydrogen = 0.09 / 24 = 0.003750 No. of moles of magnesium = 0.003750 Therefore, mass of magnesium = 0.003750 x 24 = **0.09 g** OR Volume of hydrogen is half that of curve A and magnesium is the limiting reactant. Hence mass of magnesium = 0.18 / 2 = **0.09 g**	[1] [1]
10(d)	The reaction stopped very quickly because when calcium reacts with sulfuric acid, **a layer of insoluble calcium sulfate coats over the calcium**. Hence, **some calcium remains unreacted**, resulting in less hydrogen produced.	[1] [1]
11 Either		
11(a)	Lean burn engines uses more air so more nitrogen gas can burn in oxygen;	[1]
11(b)	Petrol engines produce less soot; petrol is easier to burn completely; petrol engines produce less oxides of nitrogen;	[1]
11(c)	Honeycomb type as it is smaller;	[1]
11(d)	$2(NH_2)_2CO + 3NO_2 \rightarrow \frac{7}{2}N_2 + 4H_2O + 2CO_2$;	[1]
11(e)(i)	6 dm^3	[1]
11(e)(ii)	12 dm^3	[1]
11(f)	They are transition metals;	[1]
11(g)	To prevent the decomposition of DEF;	[1]
11(h)	It produces carbon dioxide which is a greenhouse gas; excessive amount leads to global warming which results in melting of polar ice caps;	[1] [1]
11 OR		
11(a)	400 °C, 500 atm	[1]
11(b)	When more ammonia is formed, the total number of moles of gases reduces since 4 moles of reactants (nitrogen) produce 2 moles of products (ammonia). Since there are fewer particles per unit volume, pressure is reduced.	[1] [1]
11(c)	The change is 'ammonia removal'. To reduce this change, there is a tendency to produce more ammonia. Hence, removing ammonia will cause more ammonia to be formed. Or The reaction between nitrogen and ammonia is a reversible process. Thus some of the ammonia produced will be converted back into nitrogen and hydrogen.	[1] [1] [1] [1]
11(d)	The reaction is exothermic so heat is produced. When heat is applied to the system, to reduce this change, the reverse reaction which is endothermic (cold) will tend to occur to reduce the amount of heat that is applied.	[1] [1]

11(f)		[1] shape [1] label