SYDNEY GRAMMAR SCHOOL

2016
FORM V
ANNUAL EXAMINATION

Monday 29th August, 12:55 p.m.

Chemistry

General Instructions

- Working time – 2 hours
- Board-approved calculators may be used
- Write using black pen
- Draw diagrams using pencil
- A Data Sheet and Periodic Table are provided at the back of this paper
- **Write your name and Master's initials on the multiple choice answer sheet, and at the top of Question 15, 17, 21 and 25.**
- **Remove the central staple before handing in paper**

Total marks (86)

This paper consists of two parts, **Part A** and **Part B**.

Part A
Total marks **(12)**
- Attempt ALL Questions
- Allow about 15 minutes for this Part.

Part B
Total marks **(74)**
- Attempt ALL questions
- Allow about 1 hour and 45 minutes for this Part.

CHECKLIST	
Each boy should have the following:	
1 Question Paper	
1 Multiple Choice Answer Sheet	

Chemistry Classes

5CY201 – EJS/LL	5CY202 - TW	5CY203 - AKBB	5CY204 - DGB
5CY205 - MRB	5CY206 – TW/LL	5CY207 - CRMR	5CY208 - ZI

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Part A

Total marks (12)
Attempt ALL Questions
Allow about 15 minutes for this Part

Use the multiple-choice Answer Sheet.

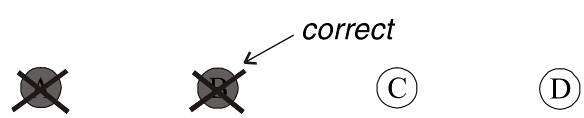
Select the alternative A, B, C or D that best answers the question. Fill the response circle completely.

Sample 2 + 4 =

(A) 2 (B) 6 (C) 8 (D) 9

If you think you have made a mistake, put a cross through the incorrect answer and fill in the new answer.

If you change your mind and have crossed out what you consider to be the correct answer, then indicate this by writing the word *correct* and drawing an arrow as follows.



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(A) Different structural forms of an element.
(B) Atoms with the same number of protons but differing number of neutrons.
(C) Compounds that have the same molecular formula but different structural formula.
(D) The different phases of a substance (e.g. gas, liquid or solid).

2 Which one of the following statements most accurately relates the properties of a liquid at room temperature to its vapour pressure?

(A) A liquid with a high vapour pressure will probably have strong intermolecular forces and a low boiling point.
(B) A liquid with a high vapour pressure will probably have low surface tension and a high boiling point.
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3 Which one of the following processes is endothermic?

(A) Combustion of natural gas.
(B) Freezing of water to make ice.
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(D) Dilute acid reacting with an active metal.

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(A) A catalyst reacts with the products to speed up the reaction.
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5 Solder is an alloy of lead and tin. A useful property of solder is that:

(A) it is lustrous, like lead and tin.
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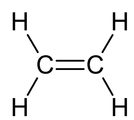
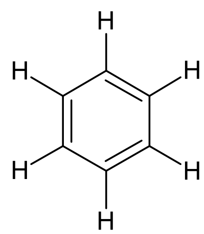
(i) 	(ii) $H-C\equiv C-CH_3$
(iii) 	(iv) $H-C\equiv C-H$

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(B) (ii) and (iii)
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(D) None of the above

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(A) Hydrogen chloride, hydrogen sulfide, water.
(B) Ammonia, phosphorus trifluoride, carbon dioxide.
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11 Identify which row below contains the correct information about the boiling and electrolysis of water.

	Type of separation	**Amount of energy required**	**Result of Process**
(A)	Boiling	Relatively large amount of energy	New chemical substance formed
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(A) They express the simplest ratio of protons to neutrons present in a compound.
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Part B
Total marks (74)
Attempt ALL Questions

Answer the questions in the spaces provided.
Show **all** relevant working in questions involving calculations.

Question 13 (6 marks) **Marks**

(a) Write balanced chemical equations for the following reactions:

i. Decomposition of silver chloride.

____ **2**

ii. Reaction of aqueous solutions of barium nitrate and copper(II) sulfate.

____ **2**

(b) Write a balanced net ionic equation for the following reaction:

i. Reaction of aqueous solutions of lead(II) nitrate and potassium iodide.

____ **2**

Question 14 (5 marks) **Marks**

During the course of this year you have performed a first-hand investigation to separate a naturally occurring mixture of sand, salt and water.

(a) Identify the separation technique you used to perform the separation of the sand from salt water and state the physical property which enabled this technique. **2**

(b) One of your classmates was given a sample of this mixture and asked to perform a gravimetric analysis of it. He found that at 22 °C the sample contained 0.573 L of water (density at 22 °C is 0.9978 g mL^{-1}), 7.8 g of sand and 2.6 g of salt.

Determine the percentage composition by mass of **water** in this sample. **3**

Question 15 (3 marks) **Marks**

Consider the representation of an atom shown below.

$$^{A}_{Z}X$$

Using the letters in the representation above, identify:

(a) The number of protons in this atom.

____ 1

(b) The number of neutrons in this atom.

____ 1

(c) An expression for the number of electrons found in an ion of this element if the element belongs to group 5 of the periodic table.

____ 1

Question 16 (3 marks) **Marks**

Identify the property or substance represented by the letters X, Y and Z in the table below.

Group	Metals	Metalloids	Non-metals
Appearance	lustrous	Low-sheen	dull
Electrical Conductivity	High	low	Y
Thermal Conductivity	high	high	low
Malleability	X	moderate	low
Density	high	intermediate	low
Boiling point	high	high	low
Tensile strength	High	variable	low
Examples	Zinc	Z	Argon

X : ____ **1**

Y : ____ **1**

Z : ____ **1**

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Question 17 (5 marks) **Marks**

Both ionic compounds and metallic elements are most commonly found as lattice structures. Compare these two types of lattice structures in terms of their structure and bonding.

5

Question 18 (2 marks)

Chemical reactions involve energy transformations. Describe a chemical reaction that you have observed that involves the transformation of light energy to chemical potential energy and provide an equation for this process.

2

Question 19 (6 marks) **Marks**

Hydrogen fluoride can be prepared according to the equation:

$$H_{2(g)} + F_{2(g)} \rightarrow 2\ HF_{(g)} \qquad \Delta H = -275 \text{ kJ mol}^{-1}$$

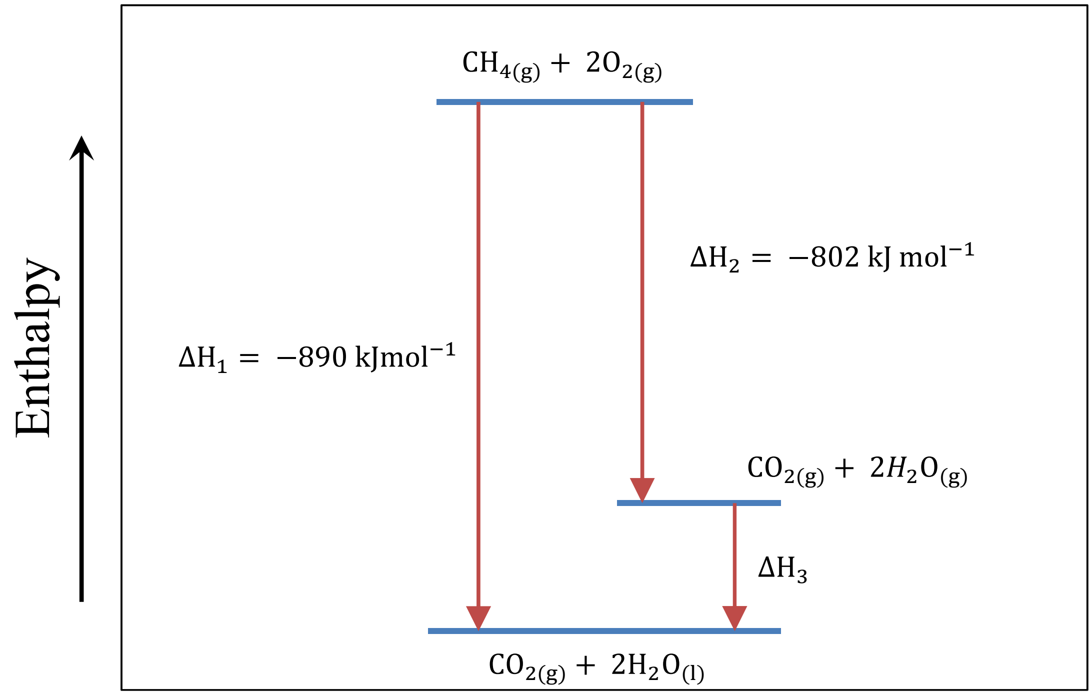
It is estimated that the activation energy for this reaction to proceed is 160 kJ mol^{-1}.

(a) Draw a labelled energy profile diagram to represent this reaction. **3**

(b) Using collision theory, explain what the effect on the reaction rate would be if the temperature was increased. **3**

Question 20 (7 marks) **Marks**

Hess's Law states that the total enthalpy change during the complete course of a chemical reaction is the same irrespective of the pathway taken i.e. whether the reaction is made in one step or in several steps. Consider the following example for the complete combustion of methane.



(a) If Hess's Law holds for the above example, calculate ΔH_3. **2**

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Question 20 continued on next page.

(b) Identify the fourth member of the homologous series of which methane is the first member.

____ **1**

(c) Identify the original source of the chemical potential energy found in methane.

____ **1**

(d) Write an equation for the incomplete combustion of methane.

____ **1**

(e) Explain why the incomplete combustion of hydrocarbons like methane is undesirable.

____ **2**

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Master's initials

Name

Question 21 (3 marks) **Marks**

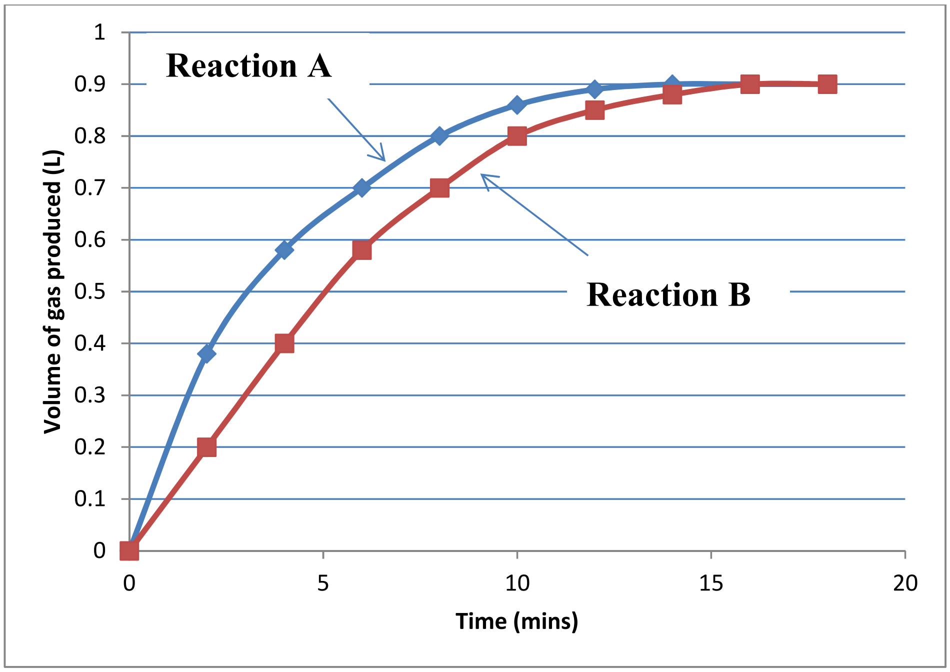
With reference to the tabulated first ionisation energies below, explain the differences in reactivity between potassium and rubidium.

Metal	First Ionisation Energy ($kJ\ mol^{-1}$)
Potassium	425
Rubidium	403

3

Question 22 (6 marks) **Marks**

Excess copper(II) carbonate was placed in a conical flask and 100.0 mL of dilute sulfuric acid was added. A reaction occurred and the gas produced was collected. The volume of gas collected at 100 kPa and 25 °C is shown in the graph below for Reaction A.



(a) Calculate the concentration of the sulfuric acid. **3**

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Question 22 continued on next page.

Question 22 continued. **Marks**

(b) A second reaction with the same mass of copper(II) carbonate and volume of acid was carried out and the results shown in Reaction B. Identify the possible conditions that could have changed to produce this graph and explain their effects. **3**

Question 23 (7 marks)

Solutions of $FeCl_{2(aq)}$ oxidise easily in the presence of oxygen to produce $FeCl_{3(aq)}$. Iron filings can be added to stabilise these solutions by reducing any $FeCl_{3(aq)}$ formed back to $FeCl_{2(aq)}$ according to the following equation.

$$Fe_{(s)} + 2FeCl_{3(aq)} \longrightarrow 3FeCl_{2(aq)}$$

(a) Write the net ionic equation for this reaction. **1**

(b) Write the reduction and oxidation half equations for these reactions.

(i) Reduction **1**

(ii) Oxidation **1**

(c) Calculate the mass of $FeCl_3$ can be reduced completely to $FeCl_2$ by 1.00 g of $Fe_{(s)}$. **4**

Question 24 (4 marks) **Marks**

2.67 L of vapourised phosphorus molecules are reacted with 8.01 L of oxygen gas at a constant temperature and pressure to produce 2.67 L of a gaseous oxide of phosphorus having a molar mass of 220 g mol^{-1}.

(a) Balance the given equation below for the reaction.

$$P_{x(g)} + O_{2(g)} \rightarrow P_xO_{y(g)}$$ 1

(b) Determine the formula of the oxide of phosphorus. Show working. 2

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____

____

(c) Determine the molecular formula of the vapourised phosphorus molecules. 1

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Master's initials

Name

Question 25 (6 marks) **Marks**

(a) Construct Lewis dot diagrams of the following molecules

(i) methane **1**

(ii) water **1**

(iii) hydrogen sulfide (H_2S) **1**

(b) Explain why the boiling points of water and hydrogen sulfide differ. **3**

Question 26 (5 marks) **Marks**

In an experiment, a boy added 8.00 g of ammonium nitrate to 100 g of water.

(a) If the $\Delta_{sol}H$ for ammonium nitrate is + 25.41 kJ mol^{-1} and the water was initially 25.0 °C, calculate the final temperature of the resulting solution. **3**

(b) The boy actually measured a final temperature of 22.1 °C. Suggest two possible reasons as to why there is a difference between these results. **2**

Question 27 (6 marks) **Marks**

Compound **A** is a white insoluble mineral made of four elements. When 10.000 g of compound **A** is reacted with 2 M HCl, 2.6886 L of CO_2 (measured at 25 °C and 100 kPa), is evolved. Na_2SO_4 is then added to the solution forming 7.383 g of compound **B** as a precipitate; compound **C** remains in solution.

The solution of compound **C** is neutralised with 2 M NaOH forming 3.1628 g of a precipitate of compound **D**, which was filtered. The 3.1628 g of Compound **D** was then heated to produce 2.1859 g of compound **E** and water. Compound **E** was heated at 2300 °C with excess carbon to give CO and 1.3183 g of pure metal **F**.

What are the formulae of compounds **A-F**? Show working.

6

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Chemistry

Data Sheet

Avogadro's constant, N_A ……………………………………… 6.022×10^{23} mol^{-1}

Volume of 1 mole ideal gas: at 100 kPa and

at 0 °C (273 K) ………………………… 22.71L

at 25 °C (298 K) ………………………. 24.79 L

Ionisation constant for water at 25°C (298.15 K), K_w …………… 1.0×10^{-14}

Specific heat capacity of water ……………………………… 4.18×10^{3} $Jkg^{-1}K^{-1}$

Some useful formulae

$pH = -\log_{10}[H^+]$ $q = mC\Delta T$

Standard Potentials

$K^+ + e^-$	$\rightleftharpoons$	$K_{(s)}$	–2.94 V
$Ba^{2+} + 2e^-$	$\rightleftharpoons$	$Ba_{(s)}$	–2.91 V
$Ca^{2+} + 2e^-$	$\rightleftharpoons$	$Ca_{(s)}$	–2.87 V
$Na^+ + e^-$	$\rightleftharpoons$	$Na_{(s)}$	–2.71 V
$Mg^{2+} + 2e^-$	$\rightleftharpoons$	$Mg_{(s)}$	–2.36 V
$Al^{3+} + 3e^-$	$\rightleftharpoons$	$Al_{(s)}$	–1.68 V
$Mn^{2+} + 2e^-$	$\rightleftharpoons$	$Mn_{(s)}$	–1.18 V
$H_2O + e^-$	$\rightleftharpoons$	$\frac{1}{2} H_{2(g)} + OH^-$	–0.83 V
$Zn^{2+} + 2e^-$	$\rightleftharpoons$	$Zn_{(s)}$	–0.76 V
$Fe^{2+} + 2e^-$	$\rightleftharpoons$	$Fe_{(s)}$	–0.44 V
$Ni^{2+} + 2e^-$	$\rightleftharpoons$	$Ni_{(s)}$	–0.24 V
$Sn^{2+} + 2e^-$	$\rightleftharpoons$	$Sn_{(s)}$	–0.14 V
$Pb^{2+} + 2e^-$	$\rightleftharpoons$	$Pb_{(s)}$	–0.13 V
$H^+ + e^-$	$\rightleftharpoons$	$\frac{1}{2} H_{2(g)}$	0.00 V
$SO_4^{2-} + 4H^+ + 2e^-$	$\rightleftharpoons$	$SO_{2(g)} + 2H_2O$	0.16 V
$Cu^{2+} + 2e^-$	$\rightleftharpoons$	$Cu_{(s)}$	0.34 V
$\frac{1}{2} O_{2(g)} + H_2O + 2e^-$	$\rightleftharpoons$	$2OH^-$	0.40 V
$Cu^+ + e^-$	$\rightleftharpoons$	$Cu_{(s)}$	0.52 V
$\frac{1}{2} I_{2(s)} + e^-$	$\rightleftharpoons$	I^-	0.54 V
$\frac{1}{2} I_{2(aq)} + e^-$	$\rightleftharpoons$	I^-	0.62 V
$Fe^{3+} + e^-$	$\rightleftharpoons$	Fe^{2+}	0.77 V
$Ag^+ + e^-$	$\rightleftharpoons$	$Ag_{(s)}$	0.80 V
$\frac{1}{2} Br_{2(l)} + e^-$	$\rightleftharpoons$	Br^-	1.08 V
$\frac{1}{2} Br_{2(aq)} + e^-$	$\rightleftharpoons$	Br^-	1.10 V
$\frac{1}{2} O_2 + 2H^+ + 2e^-$	$\rightleftharpoons$	H_2O	1.23 V
$\frac{1}{2} Cr_2O_7^{2-} + 7H^+ + 3e^-$	$\rightleftharpoons$	$Cr^{3+} + \frac{7}{2} H_2O$	1.36 V
$\frac{1}{2} Cl_{2(g)} + e^-$	$\rightleftharpoons$	Cl^-	1.36 V
$\frac{1}{2} Cl_{2(aq)} + e^-$	$\rightleftharpoons$	Cl^-	1.40 V
$MnO_4^- + 8H^+ + 5e^-$	$\rightleftharpoons$	$Mn^{2+} + 4H_2O$	1.51 V
$\frac{1}{2} F_{2(g)} + e^-$	$\rightleftharpoons$	F^-	2.89 V

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number	79
Symbol	Au
Standard Atomic Weight	197.0
Name	Gold

1 H 1.008 Hydrogen																	2 He 4.003 Helium
3 Li 6.941 Lithium	4 Be 9.012 Beryllium											5 B 10.81 Boron	6 C 12.01 Carbon	7 N 14.01 Nitrogen	8 O 16.00 Oxygen	9 F 19.00 Fluorine	10 Ne 20.18 Neon
11 Na 22.99 Sodium	12 Mg 24.31 Magnesium											13 Al 26.98 Aluminium	14 Si 28.09 Silicon	15 P 30.97 Phosphorus	16 S 32.07 Sulfur	17 Cl 35.45 Chlorine	18 Ar 39.95 Argon
19 K 39.10 Potassium	20 Ca 40.08 Calcium	21 Sc 44.96 Scandium	22 Ti 47.87 Titanium	23 V 50.94 Vanadium	24 Cr 52.00 Chromium	25 Mn 54.94 Manganese	26 Fe 55.85 Iron	27 Co 58.93 Cobalt	28 Ni 58.69 Nickel	29 Cu 63.55 Copper	30 Zn 65.38 Zinc	31 Ga 69.72 Gallium	32 Ge 72.64 Germanium	33 As 74.92 Arsenic	34 Se 78.96 Selenium	35 Br 79.90 Bromine	36 Kr 83.80 Krypton
37 Rb 85.47 Rubidium	38 Sr 87.61 Strontium	39 Y 88.91 Yttrium	40 Zr 91.22 Zirconium	41 Nb 92.91 Niobium	42 Mo 95.96 Molybdenum	43 Tc Technetium	44 Ru 101.1 Ruthenium	45 Rh 102.9 Rhodium	46 Pd 106.4 Palladium	47 Ag 107.9 Silver	48 Cd 112.4 Cadmium	49 In 114.8 Indium	50 Sn 118.7 Tin	51 Sb 121.8 Antimony	52 Te 127.6 Tellurium	53 I 126.9 Iodine	54 Xe 131.3 Xenon
55 Cs 132.9 Caesium	56 Ba 137.3 Barium	57–71 Lanthanoids	72 Hf 178.5 Hafnium	73 Ta 180.9 Tantalum	74 W 183.9 Tungsten	75 Re 186.2 Rhenium	76 Os 190.2 Osmium	77 Ir 192.2 Iridium	78 Pt 195.1 Platinum	79 Au 197.0 Gold	80 Hg 200.6 Mercury	81 Tl 204.4 Thallium	82 Pb 207.2 Lead	83 Bi 209.0 Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon
87 Fr Francium	88 Ra Radium	89–103 Actinoids	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium						

Lanthanoids

57 La 138.9 Lanthanum	58 Ce 140.1 Cerium	59 Pr 140.9 Praseodymium	60 Nd 144.2 Neodymium	61 Pm Promethium	62 Sm 150.4 Samarium	63 Eu 152.0 Europium	64 Gd 157.3 Gadolinium	65 Tb 158.9 Terbium	66 Dy 162.5 Dysprosium	67 Ho 164.9 Holmium	68 Er 167.3 Erbium	69 Tm 168.9 Thulium	70 Yb 173.1 Ytterbium	71 Lu 175.0 Lutetium

Actinoids

89 Ac Actinium	90 Th 232.0 Thorium	91 Pa 231.0 Protactinium	92 U 238.0 Uranium	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

Elements with atomic numbers 112 and above have been reported but not fully authenticated.

Standard atomic weights are abridged to four significant figures.

Elements with no reported values in the table have no stable nuclides.

The International Union of Pure and Applied Chemistry Periodic Table of the Elements (February 2010 version) is the principal source of data. Some data may have been modified.

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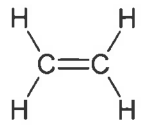
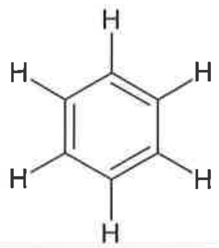
(i) 	(ii) $H-C\equiv C-CH_3$
(iii) 	(iv) $H-C\equiv C-H$

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minus 1 for each mistake

ii. Reaction of aqueous solutions of barium nitrate and copper(II) sulfate.

$Ba(NO_3)_{2(aq)} + CuSO_{4(aq)} \rightarrow Cu(NO_3)_{2(aq)} + BaSO_{4(s)}$ 2

(b) Write a balanced net ionic equation for the following reaction:

i. Reaction of aqueous solutions of lead(II) nitrate and potassium iodide.

$Pb^{2+}_{(aq)} + 2I^-_{(aq)} \rightarrow PbI_{2(s)}$ MINUS 1 FOR EACH MISTAKE 2

Many boys had several bites at the cherry, writing the equation in different forms. Boys were penalised for each mistake they made, although not for writing several equations. This will not necessarily be the case in future exams (ie HSC).

Question 14 (5 marks) **Marks**

During the course of this year you have performed a first-hand investigation to separate a naturally occurring mixture of sand, salt and water.

(a) Identify the separation technique you used to perform the separation of the sand from salt water and state the physical property which enabled this technique. **2**

Filtration 1 MARK

Particle Size / Solubility 1 MARK

(b) One of your classmates was given a sample of this mixture and asked to perform a gravimetric analysis of it. He found that at 22 °C the sample contained 0.573 L of water (density at 22 °C is 0.9978 g mL^{-1}), 7.8 g of sand and 2.6 g of salt.

Determine the percentage composition by mass of **water** in this sample. **3**

Mass of Water $= 0.9978 \times 0.573 \times 10^{+3}$

$= 5.7174 \times 10^{2}$ g 1 MARK

Total mass $= 5.7174 \times 10^{2} + 7.8 + 2.6$ 1 MARK

$= 582.14$ g

% Comp $= \frac{571.74}{582.14} \times 100 = 98.2\%$ 1 MARK

Question 15 (3 marks) **Marks**

Consider the representation of an atom shown below.

$${}^{A}_{Z}X$$

Using the letters in the representation above, identify:

(a) The number of protons in this atom.

Z 1

(b) The number of neutrons in this atom.

$A - Z$ 1

(c) An expression for the number of ~~valence~~ electrons found in an ion of this element if the element belongs to group 5 of the periodic table.

$Z + 3$ 1

Valence electrons 8, 18, 32....

Question 16 (3 marks) **Marks**

Identify the property or substance represented by the letters X, Y and Z in the table below.

Group	**Metals**	**Metalloids**	**Non-metals**
Appearance	lustrous	Low-sheen	dull
Electrical Conductivity	High	low	Y
Thermal Conductivity	high	high	low
Malleability	X	moderate	low
Density	high	intermediate	low
Boiling point	high	high	low
Tensile strength	High	variable	low
Examples	Zinc	Z	Argon

X: High/good **1**

Y: ~~Any~~ Low/poor **1**

Z: ~~Low/poor~~ any **1**

CRIB - MTK

Question 17 (5 marks) **Marks**

Both ionic compounds and metallic elements are most commonly found as lattice structures. Compare these two types of lattice structures in terms of their structure and bonding.

Marked holistically.
5 marks required detailed discussion of S&B of both metals and ionic compounds, plus gives a direct comparison between them. Following codes for used to indicate what was missing or insufficiently covered (-1 per item):

C - explicit comparison missing
IB – ionic bonding
IS – ionic structure
MB – metallic bonding
MS – metallic structure
D – lacks depth

Sample answer

Metallic elements' structure involves a 3-D lattice of metal cations in a sea of delocalised electrons. The bonding is due to the electrostatic attraction between the metal's positive nuclei and the electrons. Ionic compounds also have a 3D lattice structure – but they have an array of repeating units of alternating cations and anions. These ions are also bonded by electrostatic attraction but this time it is between the fixed cations and anions and there are no free electrons. This ionic bonding makes the lattice structure very rigid (shatters when hit) compared to the easily malleable lattice structure of metals (as the free electrons can readily relocate to ensure the metallic bonds stay in place as the metal is beaten).

Question 18 (2 marks)

Chemical reactions involve energy transformations. Describe a chemical reaction that you have observed that involves the transformation of light energy to chemical potential energy and provide an equation for this process.

1 mark – description of reaction (e.g. decomposition of silver halides; photosynthesis)
1 mark – balanced chemical equation (note: word equations not accepted)

Question 19 (6 marks) **Marks**

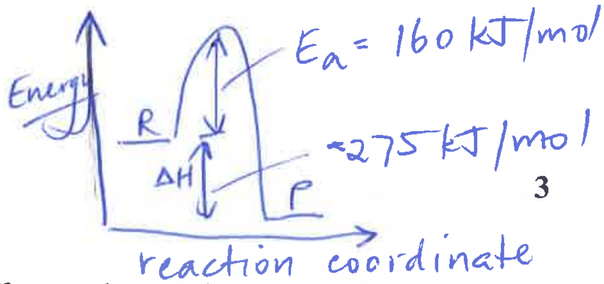
Hydrogen fluoride can be prepared according to the equation:

$$H_{2(g)} + F_{2(g)} \rightarrow 2\ HF_{(g)} \qquad \Delta H = -275\ kJ\ mol^{-1}$$

It is estimated that the activation energy for this reaction to proceed is 160 kJ mol^{-1}.

(a) Draw a labelled energy profile diagram to represent this reaction.

1 mark – exothermic diagram
1 mark – labelling ΔH = -275 on diagram
1 mark – labelling activation energy



3

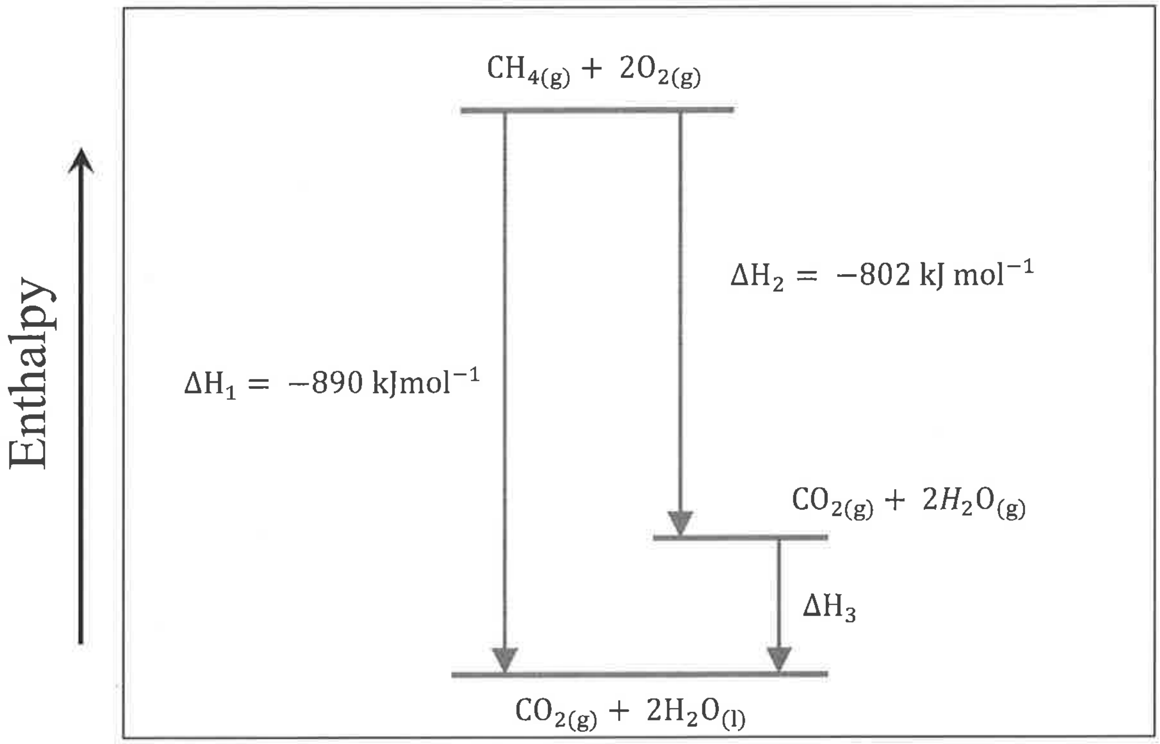
(b) Using collision theory, explain what the effect on the reaction rate would be if the temperature was increased.

3

1 mark – more frequent collisions
1 mark – more particles have sufficient energy to overcome activation barrier
1 mark – increase in reaction rate

Question 20 (7 marks) **Marks**

Hess's Law states that the total enthalpy change during the complete course of a chemical reaction is the same irrespective of the pathway taken i.e. whether the reaction is made in one step or in several steps. Consider the following example for the complete combustion of methane.



(a) If Hess's Law holds for the above example, calculate ΔH_3.

2 marks - calculating -88 kJ/mol

1 mark for +88 kJ/mol 2

(b) Identify the fourth member of the homologous series of which methane is the first member.

butane 1

(c) Identify the original source of the chemical potential energy found in methane.

The sun 1

(d) Write an equation for the incomplete combustion of methane.

Any correctly balanced chemical equation showing production of either C or CO 1

e.g. $CH_4 + 3/2\ O_2 \rightarrow CO + 2\ H_2O$ – states were ignored.

(e) Explain why the incomplete combustion of hydrocarbons like methane is undesirable.

2 marks – explanation of two problems with incomplete combustion e.g. soot or CO or inefficient energy output. Needed to have detail of why problem exists e.g. needed more than CO is toxic; needed to explain how it caused oxygen shortage due to binding to haemoglobin.

1 mark – one of the above well explained or less detail on 2 problems. **2**

Master's initials

Name

Question 21 (3 marks) **Marks**

With reference to the tabulated first ionisation energies below, explain the differences in reactivity between potassium and rubidium.

Metal	First Ionisation Energy ($kJ\ mol^{-1}$)
Potassium	425
Rubidium	403

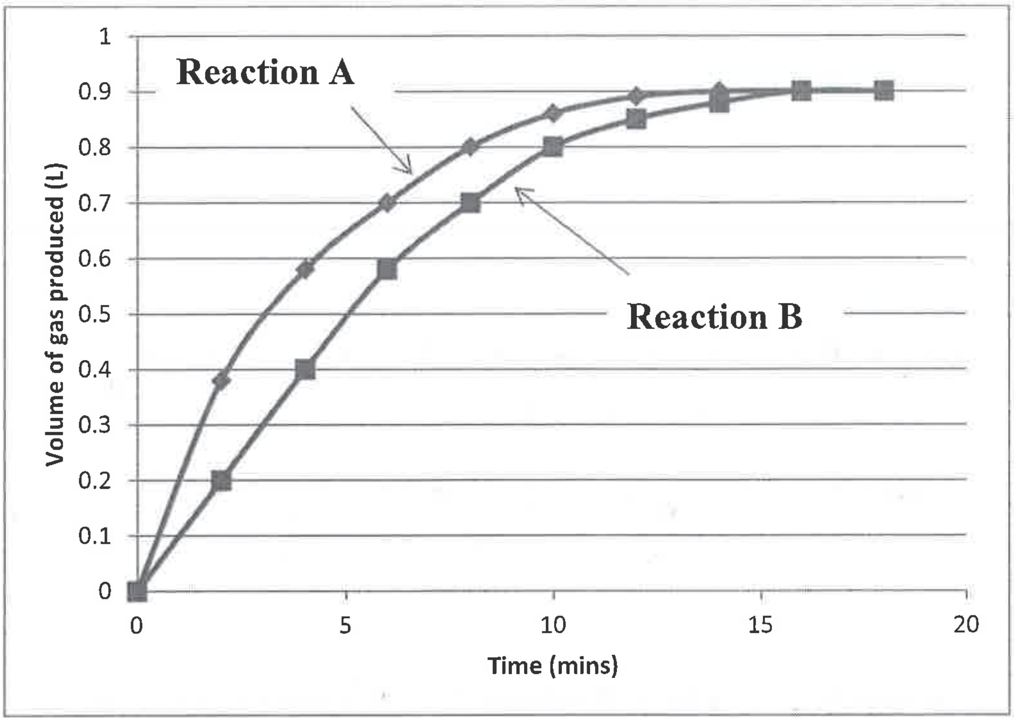
- Explain first ionization energy 3

- Correlate reduced first ionization energy to increased reactivity

- refer to Table with rubidium having lower ionization energy and hence higher reactivity.

Question 22 (6 marks) **Marks**

Excess copper(II) carbonate was placed in a conical flask and 100.0 mL of dilute sulfuric acid was added. A reaction occurred and the gas produced was collected. The volume of gas collected at 100 kPa and 25 °C is shown in the graph below for Reaction A.



(a) Calculate the concentration of the sulfuric acid. **3**

1 Mark Equation compulsory!! $CuCO_{3(s)} + H_2SO_{4(aq)} \Rightarrow CuSO_{4(aq)} + CO_{2(g)} + H_2O_{(l)}$.

1 Mark $n_{(CO_2)} = \frac{0.90}{24.79} = 0.0360 mol$.

1 Mark $n_{H_2SO_4} = n_{CO_2} = 0.03630 mol$.

$[H_2SO_4] = \frac{0.03630}{0.100} = 0.3630$ M.

correct units required!

Question 22 continued on next page.

(b) A second reaction with the same mass of copper(II) carbonate and volume of acid was carried out and the results shown in Reaction B. Identify the possible conditions that could have changed to produce this graph and explain their effects. 3

2 Reasons 1 mark Each

1 Explanation 1 mark.

Marks lost for incorrect reasons or explanations.

Reasons

- ~~Increased~~ Decreased temp of solution

- Decreased surface area of copper (II) carbonate

~~Decreased~~

Not Decreased concentration as the volume added was fixed (see comment above) and this would have led to a smaller volume of gas produced.

Explanation reactions - frequency of collision
- energy per collision.

Question 23 (7 marks)

Solutions of $FeCl_{2(aq)}$ oxidise easily in the presence of oxygen to produce $FeCl_{3(aq)}$. Iron filings can be added to stabilise these solutions by reducing any $FeCl_{3(aq)}$ formed back to $FeCl_{2(aq)}$ according to the following equation.

$$Fe_{(s)} + 2FeCl_{3(aq)} \longrightarrow 3FeCl_{2(aq)}$$

(a) Write the net ionic equation for this reaction.

$Fe_{(s)} + 2Fe^{3+}_{(aq)} \rightarrow 3Fe^{2+}_{(aq)}$ 1

(b) Write the reduction and oxidation half equations for these reactions.

(i) Reduction

$Fe^{3+}_{(aq)} + e^- \rightarrow Fe^{2+}_{(aq)}$ 1

(ii) Oxidation

$Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^-$ 1

(c) Calculate the mass of $FeCl_3$ can be reduced completely to $FeCl_2$ by 1.00 g of $Fe_{(s)}$.

1 $n_{Fe} = \frac{1.00}{55.85} = 0.01791$ mol 4

1 $n_{FeCl_3} = 2 \times n_{Fe} = \frac{2.00}{55.85} = 0.03581$ mol

1 $m_{FeCl_3} = n \times M = \frac{2.00}{55.85} \times$ ~~[illegible]~~ 162.2

$= \cancel{4.5717}$ 5.81g

$= \cancel{4.57g}$ to 3 s.f.

220
96
124

Question 24 (4 marks) **Marks**

2.67 L of vapourised phosphorus molecules are reacted with 8.01 L of oxygen gas at a constant temperature and pressure to produce 2.67 L of a ~~gaseous oxide~~ of phosphorus having a molar mass of 220 g mol^{-1}.

(a) Balance the given equation below for the reaction. **1**

$$P_{x(g)} + 3O_{2(g)} \rightarrow P_xO_{y(g)}$$

(b) Determine the formula of the oxide of phosphorus. Show working. **2**

1 mark.

y = number of oxygens = 2×3 = 6.

mass of 6 oxygens = 6×16 = 96

∴ mass of phosphorus = 220 − 96 = 124

number of phosphorus = $\frac{124}{31}$ = 4

1 mark. Formula = P_4O_6.

(c) Determine the molecular formula of the vapourised phosphorus molecules. **1**

P_4.

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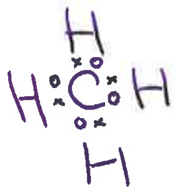
Question 25 (6 marks) **Marks**

(a) Construct Lewis dot diagrams of the following molecules

(i) methane

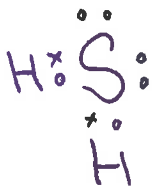


1

(ii) water

1

(iii) hydrogen sulfide (H_2S)



1

(b) Explain why the boiling points of water and hydrogen sulfide differ. 3

① Water has hydrogen bonding

② H_2S has dipole - dipole • dispersion

• ~~mainly~~ *had to say dipole dipole

③ more energy to disrupt waters intermolecular attraction therefore higher melting point.

Question 26 (5 marks) **Marks**

In an experiment, a boy added 8.00 g of ammonium nitrate to 100 g of water.

(a) If the $\Delta_{sol}H$ for ammonium nitrate is + 25.41 kJ mol^{-1} and the water was initially 25.0 °C, calculate the final temperature of the resulting solution. 3

$n_{NH_4NO_3} = \frac{8.0}{80.052}$ 1

$= 0.099935$

$q = mC\Delta T$

$-2539.348 = 100 \times 4.18 \times \Delta T$

$\Delta_{sol}H = \frac{-q}{n}$

$\Delta T = \frac{-2539.348}{418}$

$254100 = \frac{-q}{n}$ 1

$= -6.074996$

$q = -2539.348 \text{ J}$

$T_F - T_i = \Delta T$

$T_F = 25 - 6.074996$

$= 18.9°C$ 1

(b) The boy actually measured a final temperature of 22.1 °C. Suggest two possible reasons as to why there is a difference between these results. 2

1 temperature was gained from the surroundings

2 impurities in Ammonium nitrate

NOTE: for a) many used 4.18×10^3 but still left ΔH in kJ which gave the wrong value.

b) poor equipment and misreadings not accepted. Have to assume the experiment was conducted properly and carefully.

Question 27 (6 marks) **Marks**

Compound **A** is a white insoluble mineral made of four elements. When 10.000 g of compound **A** is reacted with 2 M HCl, 2.6886 L of CO_2 (measured at 25 °C and 100 kPa), is evolved. Na_2SO_4 is then added to the solution forming 7.383 g of compound **B** as a precipitate; compound **C** remains in solution.

The solution of compound **C** is neutralised with 2 M NaOH forming 3.1628 g of a precipitate of compound **D**, which was filtered. The 3.1628 g of Compound **D** was then heated to produce 2.1859 g of compound **E** and water. Compound **E** was heated at 2300 °C with excess carbon to give CO and 1.3183 g of pure metal **F**.

What are the formulae of compounds **A-F**? Show working.

(1) A must contain a carbonate as CO_2 produced. 6

$n_{CO_2} = 0.10845$ moles.

A = carbonate
B = sulfate
C = sulfate or chloride.
D = hydroxide
E = Oxide
F = pure metal.

→ Then work bottom up.

mass of O lost $= 2.1859 - 1.3183$
$= 0.8676$

$\therefore n_O = 0.054225$

so if 1:1 oxygen : metal then 0.054225 moles of metal.

$\therefore$ Molar mass metal $= \frac{\text{mass pure}}{\text{moles of O}} = \frac{1.3183}{0.054225} = 24.31$

$\therefore$ Mg (1)

so F = Mg

E = MgO (1)

D = $Mg(OH)_2$

C = $MgSO_4$ or $MgCl_2$ (1)

ratio $Mg : CO_3$
1 : 2

$\therefore A = Mg(CO_3)_2X$

$B = XSO_4$

assuming X has a minus 2 charge.

$\therefore$ 1:1

so moles X = 0.054224

$\therefore M_B = \frac{7.383}{0.054224}$
$= 136.149$,

(1)
B = $CaSO_4$

(1) A = $MgCa(CO_3)_2$

$Mw_{SO_4} = 96.07$ $\therefore Mw_X = 40.079 = Ca$

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