SYDNEY GRAMMAR SCHOOL

2014
FORM V
ANNUAL EXAMINATION

Monday 1st September, 12:55 pm

Chemistry

General Instructions

- Working time – 2 hours
- Board-approved calculators may be used
- Write using blue or 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 at the top of each page in Part B**
- **Remove the central staple before handing in paper**

Total marks (87)

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

Part A
Total marks **(13)**
- 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 - AKBB	5CY202 - CF	5CY203 - ASG	
5CY204 - EJS	5CY205 - MRB	5CY206 - TW	5CY207 - ZI

BLANK PAGE

Part A

Total marks (13)
Attempt ALL Questions
Allow about 20 minutes for this Part

Use the multiple-choice Answer Sheet.

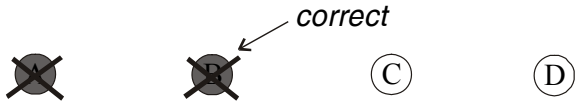
Select the alternative A, B, C or D that best answers the question. Fill the response circle completely.

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.



1 Which of the following methods would best enable you to separate two immiscible liquids?

(A) using a separating funnel
(B) using a filter funnel
(C) using evaporation
(D) using distillation

2 Which compound contains both covalent and ionic bonds?

(A) $MgBr_2$
(B) $CHCl_3$
(C) BCl_3
(D) NH_4NO_3

3 An atom of element Z (not correct symbol) has the electronic configuration 2, 8, 6. Which of the following species is this element most likely to form?

(A) the ion Z^{2+}
(B) the ion Z^{6+}
(C) the compound H_2Z
(D) the compound Z_6F

4 The first four successive ionisation energies (measured in kJ mol^{-1}) for an element are 550, 1064, 4210 and 5500. This element should be placed in the same group as:

(A) lithium
(B) beryllium
(C) boron
(D) carbon

5 Topaz is a mineral with the formula $Al_2SiO_4(OH)_2$. What is the percentage by mass of aluminium in topaz?

(A) 15%
(B) 16%
(C) 30%
(D) 45%

6 A boy was investigating the reactivity of three unknown metals (X, Y and Z) using displacement reactions. He recorded the following balanced chemical equations:

$$X(NO_3)_{2(aq)} + Z_{(s)} \rightarrow X_{(s)} + Z(NO_3)_{2(aq)}$$

$$Z_{(s)} + Y(NO_3)_{2(aq)} \rightarrow Y_{(s)} + Z(NO_3)_{2(aq)}$$

$$Y_{(s)} + X(NO_3)_{2(aq)} \rightarrow \text{no visible reaction}$$

Which of the following correctly places the three metals in order of **increasing** reactivity?

(A) Y, X, Z
(B) Z, Y, X
(C) X, Z, Y
(D) Z, X, Y

7 Which of the following best describes the molecular shape of methane?

(A) trigonal planar
(B) bent
(C) trigonal pyramidal
(D) tetrahedral

8 In which of the following substances would you expect hydrogen bonding to occur?

I. CH_2F_2
II. CH_3COOH
III. C_2H_5OH

(A) II only
(B) I and III only
(C) II and III only
(D) I, II and III

9 The specific heat capacity of gold is 0.128 J g^{-1} K^{-1}, and the specific heat capacity of copper is 0.385 J g^{-1} K^{-1}. Ten-gram samples of each metal were heated to 60 °C, and then dropped into separate beakers containing 20 mL of water.

Which of the following statements are correct?

(A) The copper will react with the water, but the gold will not.
(B) The copper sample will transfer more heat energy to the water than the gold sample.
(C) The water with the gold sample will have has a final temperature three times higher than the water with the copper sample.
(D) The water in the two beakers will remain at the same temperature at all times.

10 Wicks are used in candles to:

(A) Decrease the ignition temperature of the wax vapour.
(B) Facilitate the evaporation of the liquid wax.
(C) Prevent the whole candle surface from combusting.
(D) To attract enough heat from the rest of the candle to liquefy the wax.

11 When aqueous solutions of hydrochloric acid and sodium hydroxide are mixed, the temperature of the resulting solution increases. Therefore, the reaction

$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$$

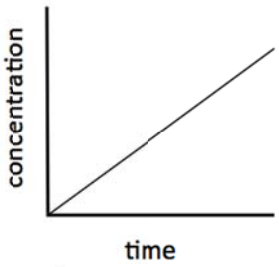
(A) is endothermic with $\Delta H^o > 0$
(B) is endothermic with $\Delta H^o < 0$
(C) is exothermic with $\Delta H^o < 0$
(D) is exothermic with $\Delta H^o > 0$

12 The energy obtained from coal is derived from:

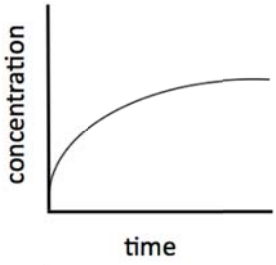
(A) The compressional energy absorbed by the coal from overlying rocks when buried deep underground.
(B) Heat energy absorbed from nearby geothermal sites.
(C) Nuclear energy absorbed by the coal from transuranic elements in the Earth's core.
(D) Light energy from the Sun absorbed by plants before they were buried and became coal.

13 Which of the following graphs best represent the change in concentration of products over time for a reaction as it goes towards completion?

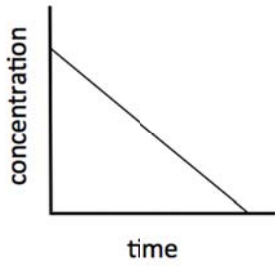
(A)



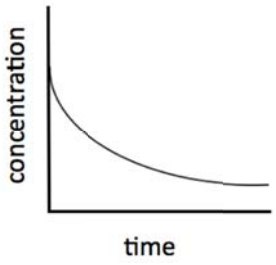
(B)



(C)



(D)



BLANK PAGE

Master's initials

Name

Part B

Total marks (74)
Attempt ALL Questions

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

Question 14 (2 marks) **Marks**

Write word equations for;

(a) the electrolysis of water.

_____ **1**

(b) photosynthesis.

_____ **1**

Question 15 (3 marks)

Write balanced chemical equations for;

(a) the decomposition of silver chloride.

_____ **1**

(b) the reaction between solutions of barium hydroxide and copper(II) sulfate.

_____ **2**

Question 16 (3 marks) **Marks**

Draw Lewis electron dot diagrams for each of the following substances.

(a) hydrogen sulfide

1

(b) nitrogen trifluoride

1

(c) ethene

1

Question 17 (4 marks) **Marks**

The table below summarises some properties of Substance **Y** and Substance **Z**. Use the information to answer the following questions.

Substance Y	Substance Z
white solid that melts at 801 °C to form colourless liquid	grey solid that melts at 419 °C and boils at 906 °C
does not conduct electricity in solid state, but is a good conductor when liquid	conducts electricity in both solid and liquid states

(a) Describe the structure and bonding of Substance **Z** at 25 °C.

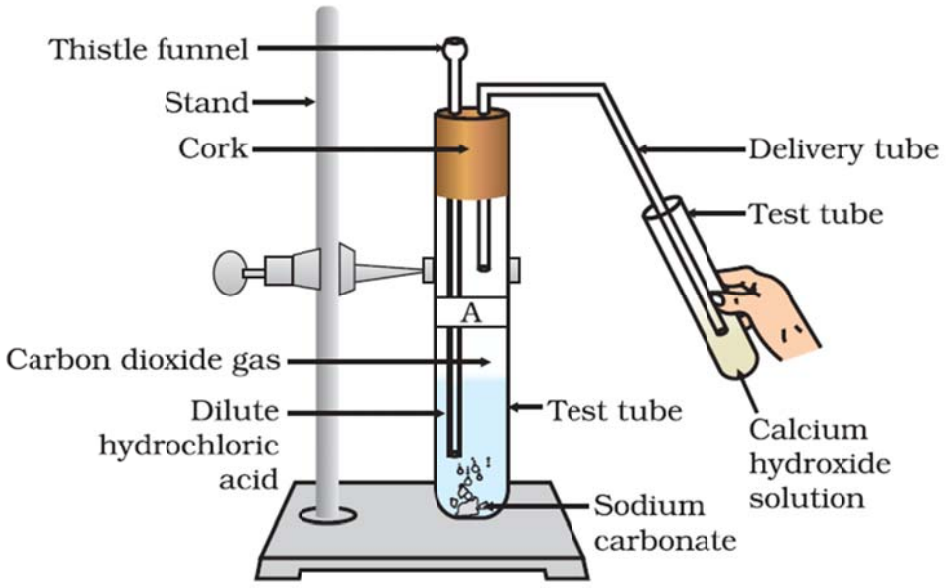
2

(b) Predict whether an aqueous solution of Substance **Y** would conduct electricity, and justify your answer in terms of the properties of Substance **Y**.

2

Question 18 (4 marks) **Marks**

The diagram below shows an experimental set up for the production of carbon dioxide.



(a) Write a balanced chemical equation for the reaction producing CO_2.

_____ **1**

(b) If 2.50 g of solid sodium carbonate was reacted with excess hydrochloric acid, calculate the **mass and volume** of carbon dioxide evolved, measured at 100 kPa and 25 ºC.

_____ **3**

_____

_____

_____

_____

_____

Question 19 (3 marks)

Explain why different isotopes of an element have the same chemical properties, but different relative atomic masses.

3

BLANK PAGE

Master's initials

Name

Question 20 (3 marks) **Marks**

The history of metal use has been intricately interwoven with the evolution of society and civilisations throughout our history. Explain, citing examples, the general trend in technological developments and access to energy with regards to mankind's ability to extract metals from their ore.

3

Question 21 (5 marks) **Marks**

The compound uracil is one of the bases found in RNA (ribonucleic acid). A 336.3 g sample of uracil was broken down into its constituent elements and found to contain 144.0 g of carbon, 12.1 g of hydrogen, 85.1 g of nitrogen, with the remaining mass being oxygen.

(a) Calculate the molar ratio of the elements in this compound and thus state its empirical formula.

3

(b) If one mole of uracil contains 28.02 g of nitrogen, calculate the molecular formula of this compound.

2

Question 22 (6 marks) **Marks**

The metal activity series can be experimentally derived using the reactions of metals with acids.

(a) Redox reactions involve the transfer of electrons. Use a balanced chemical equation and the relevant half equations to explain why the reaction of zinc with aqueous sulfuric acid can be considered to be a redox reaction.

3

(b) Not all metals react with acids. Explain why some metals will react with an acid (such as aqueous sulfuric acid), whilst others will not.

3

BLANK PAGE

Master's initials

Name

Question 23 (2 marks) **Marks**

Mendeleev is universally acknowledged as having put together the first functioning Periodic Table. Outline two decisions he made which allowed him to succeed in putting together a functioning Periodic Table when others had failed.

2

Marks

Question 24 (5 marks)

The boiling points for Group V hydrides are shown in the table below.

Hydride	Boiling point (°C)
ammonia (NH_3)	-33
phosphine (PH_3)	-88
arsine (AsH_3)	-55
stibine (SbH_3)	-17
bismuthine (BiH_3)	22

(a) Explain the general trend in boiling points observed for phosphine to bismuthine. **2**

(b) Using a diagram, explain why the boiling point of ammonia does not follow the same general trend as phosphine to bismuthine. **3**

Question 25 (5 marks) **Marks**

At 25 °C, the maximum amount of sodium chloride that will dissolve in 100 mL of water is 35.9 g.

(a) What is the concentration (in mol L^{-1}) of a saturated solution of sodium chloride at 25 °C? **2**

(b) 25.0 mL of a saturated solution of sodium chloride is diluted to 300 mL. Calculate the concentration (in mol L^{-1}) of the final solution. **1**

(c) 40.0 g of sodium chloride is added to 100 mL of deionised water at 25 °C. Using this solution as an example, describe the movement of solute particles in a saturated solution. **2**

BLANK PAGE

Master's initials

Name

Question 26 (4 marks) **Marks**

When 4.000 g of potassium hydroxide is dissolved in 100.00 g of water, the temperature of the water increases from 25.00 °C to 34.83 °C.

(a) Calculate the chemical amount of potassium hydroxide that was used. **1**

(b) Calculate the molar enthalpy of solution ($\Delta_{sol}H^{o}$, in kJ mol^{-1}) for potassium hydroxide. **3**

Question 27 (3 marks) **Marks**

The image below shows a short "thread" of water suspended between two beakers.

Explain why it is possible to produce a stable "thread" of water as shown above. **3**

Question 28 (2 marks)

A hydrocarbon will burn completely once its ignition temperature is reached, even though only a fraction of its molecules will have enough energy to react. Explain this observation.

2

Question 29 (3 marks)

Analyse the impact of increasing the temperature on reaction rate.

3

BLANK PAGE

Master's initials

Name

Question 30 (6 marks) **Marks**

Carbon has a number of different allotropic forms, including diamond and graphite.

(a) Compare the nature and geometry of the bonding in diamond and graphite.

2

(b) Under the right conditions, graphite can be converted into diamond.

$$C_{graphite} \rightarrow C_{diamond} \qquad \Delta H° = +2 \text{ kJ mol}^{-1}$$

The activation energy for this process is 120 kJ mol^{-1}.

(i) Outline why the activation energy for this process is so high.

1

(ii) Given the above information, suggest what reaction conditions would be required to convert graphite into diamond.

1

Question 30 continued on next page.

Question 30 continued.

Marks

(ii) Draw a fully labelled energy profile diagram for the reaction transforming graphite to diamond.

2

Question 31 (4 marks)

Describe a reliable experiment that you could perform in the laboratory, using magnesium and hydrochloric acid, to investigate the effect of changing concentration on reaction rate. Include the expected result of this experiment.

4

Question 32 (3 marks) **Marks**

A BBQ heat bead, comprised of a mixture of graphite and clay, was placed in a container. An excess of oxygen gas was passed over the heat bead as it was being combusted. The graphite underwent complete combustion, but the clay remained unchanged. Masses of the container and its contents were documented during the experiment along with the mass of CO_2 produced.

Determine the percentage by mass of graphite in the BBQ heat bead using the information in the table below.

Item	Mass (kg)
reaction container	2.45
reaction container with heat beads before combustion	3.75
evolved CO_2	2.89

3

BLANK PAGE

Master's initials

Name

Question 33 (4 marks) **Marks**

The following information refers to the reactions of an unknown compound, Compound **Y**. Compound **Y** is a molecular gas composed of nitrogen and oxygen. All gas volumes are measured at 25 ºC and 100 kPa. **4**

- Compound **Y** can be prepared by the reaction of another gas, Compound **X**, with oxygen. In this reaction, 1.00 L of Compound **X** reacts with 0.500 L of oxygen to produce 1.00 L of Compound **Y**.

- Compound **Y** will react with lead(II) oxide to produce Compound **X** and a white solid, Compound **Z**. In this reaction, 3.00 g of lead(II) oxide will react with 1.00 L of Compound **Y**, to produce 4.45 g of Compound **Z** and 0.333 L of Compound **X**. Compound **Z** is soluble in water.

- Compound **Y** has the interesting property that it can be used as a source of oxygen to promote combustion reactions. For example, it can be used as the oxygen source for the complete combustion of hydrocarbons, so that oxygen gas does not need to be used.

Showing all necessary logic, write balanced chemical equations for the three chemical reactions below. Ensure you clearly identify the formulae of Compounds **X**, **Y** and **Z**;

a) The reaction of Compound **X** with oxygen to produce Compound **Y**.
b) The reaction of Compound **Y** with lead(II) oxide to produce Compound **Z** and Compound **X**.
c) The reaction of methane and Compound **Y**.

BLANK PAGE

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

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

Standard Potentials

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

PERIODIC TABLE OF THE ELEMENTS

KEY

Atomic Number
Symbol
Standard Atomic Weight
Name

79 Au 197.0 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.

SYDNEY GRAMMAR SCHOOL

Class

Name

Chemistry

2014
FORM V
ANNUAL EXAMINATION

Part A
ANSWER SHEE

1. (A) B C D
2. A B C (D)
3. A B (C) D
4. A (B) C D
5. A B (C) D
6. (A) B C D
7. A B C (D)
8. A B (C) D
9. A (B) C D
10. A (B) C D
11. A B (C) D
12. A B C (D)
13. A (B) C D

General Instructions

- Write your class and candidate number in the space provided.
- Attempt all questions 1 – 13
- Use a blue or black pen
- Select the alternative A, B, C, or D that best answers the question.
- Fill in the response circle completely.

TOTAL = 19

Part B
Total marks (74)
Attempt ALL Questions

Master's initials: CRB

Name

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

Question 14 (2 marks) **Marks**

NOTE: Boys still chose to write balanced chemical equations. (1 mark maximum if correct).

Write word equations for;

(a) the electrolysis of water.

liquid water ⟶ oxygen gas + hydrogen gas. **1**

(b) photosynthesis.

water + carbon dioxide ⟶ oxygen gas + glucose. **1**

Question 15 (3 marks)

Write balanced chemical equations for;

(a) the decomposition of silver chloride.

$2AgCl_{(s)} \rightarrow 2Ag_{(s)} + Cl_{2(g)}$ **1**

states not penalised here.
Boys still don't know chlorine is diatomic

(b) the reaction between solutions of barium hydroxide and copper(II) sulfate.

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

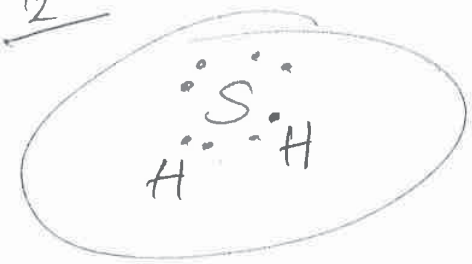
NOTE: Two solid products!

Question 16 (3 marks) **Marks**

NOTE: Some boys didn't do this for ethene – rather structural formula.

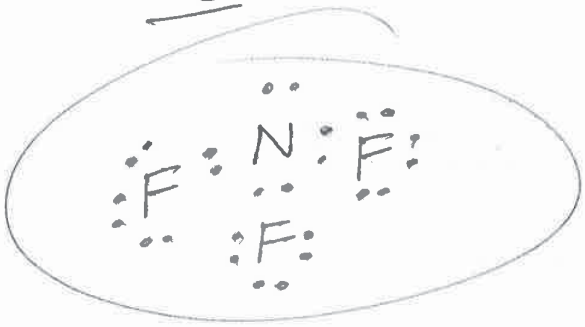
Draw Lewis electron dot diagrams for each of the following substances.

(a) hydrogen sulfide H_2S



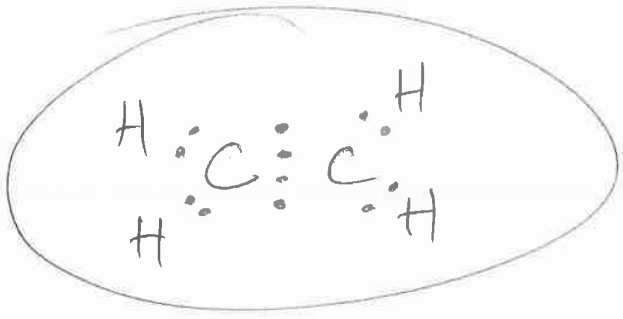
1

(b) nitrogen trifluoride NF_3



1

(c) ethene C_2H_4



1

Question 17 (4 marks) **Marks**

The table below summarises some properties of Substance **Y** and Substance **Z**. Use the information to answer the following questions.

Substance Y	Substance Z
white solid that melts at 801 °C to form colourless liquid	grey solid that melts at 419 °C and boils at 906 °C
does not conduct electricity in solid state, but is a good conductor when liquid	conducts electricity in both solid and liquid states

(a) Describe the structure and bonding of Substance **Z** at 25 °C. **2**

(1mark) 3D lattice structure

→ cations attracted to delocalised electrons. (1mark)

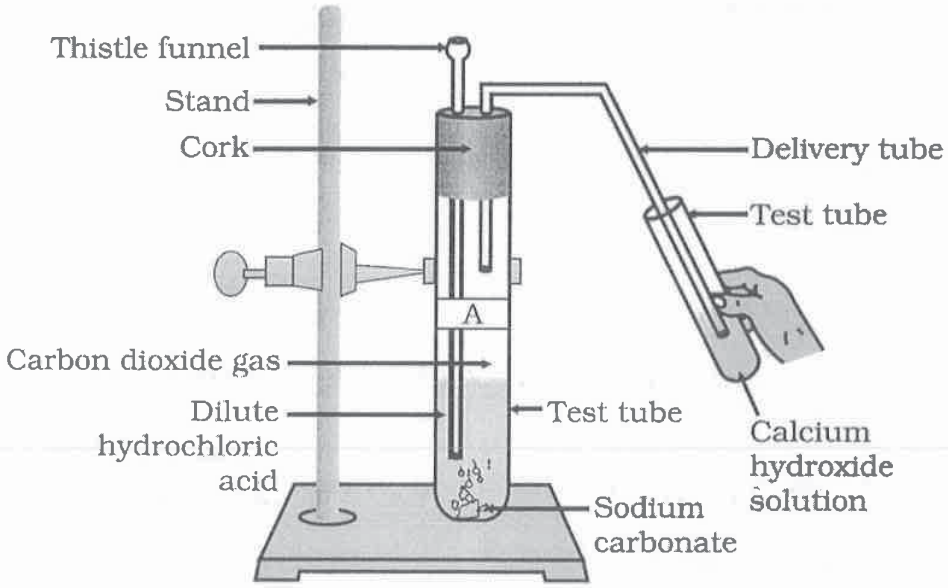
(b) Predict whether an aqueous solution of Substance **Y** would conduct electricity, and justify your answer in terms of the properties of Substance **Y**. **2**

(1mark) It will conduct as it is an ionic compound (note properties in table)

(1mark) cations and anions will be free to move in solution and carry charge. (conduct)

Question 18 (4 marks) **Marks**

The diagram below shows an experimental set up for the production of carbon dioxide.



(a) Write a balanced chemical equation for the reaction producing CO_2.

$Na_2CO_{3(s)} + 2HCl_{(aq)} \rightarrow 2NaCl_{(aq)} + CO_{2(g)} + H_2O_{(l)}$ 1

NOTE: states not penalised here.

(b) If 2.50 g of solid sodium carbonate was reacted with excess hydrochloric acid, calculate the **mass and volume** of carbon dioxide evolved, measured at 100 kPa and 25 °C.

(1 mark) $n(Na_2CO_3) = \frac{2.5g}{106} = 0.024$ moles 3

$\therefore$ 0.024 moles of $CO_{2(g)}$ produced (1:1 mole ratio)

(1 mark) 0.024×44 (Fw CO_2) $= 1.04g$ of $CO_{2(g)}$ produced

(1 mark) $0.024 \times 24.79 = 0.58L$ of $CO_{2(g)}$ produced

NOTE: Carry over error considered if original equation incorrect and/or original number of moles miscalculated.

Question 19 (3 marks)

Explain why different isotopes of an element have the same chemical properties, but different relative atomic masses.

(1 mark) Decent definition of isotope. Same element, but with a different number of neutrons
- must mention protons/electrons the same

3

(1 mark) Neutron number affects the atomic mass

(1 mark) Electrons (valance/total) affect the chemical properties (together with protons)

NOTE: must explicitly state why chemical properties are the same

Not just - "neutrons are not responsible for chemical properties ...."

many answers!

BLANK PAGE

Master's initials

Name

Question 20 (3 marks) **Marks**

The history of metal use has been intricately interwoven with the evolution of society and civilisations throughout our history. Explain, citing examples, the general trend in technological developments and access to energy with regards to mankind's ability to extract metals from their ore.

3

- Increased access to energy or better mining techniques / meant a greater variety of metals could be extracted (1)
- Specific example of named metal and new technology which has allowed its extraction (1)
- Increased access to energy has allowed us to purify increasingly reactive metals which requires breaking increasingly strong bonds.

Question 21 (5 marks) **Marks**

The compound uracil is one of the bases found in RNA (ribonucleic acid). A 336.3 g sample of uracil was broken down into its constituent elements and found to contain 144.0 g of carbon, 12.1 g of hydrogen, 85.1 g of nitrogen, with the remaining mass being oxygen.

(a) Calculate the molar ratio of the elements in this compound and thus state its empirical formula. **3**

Mass of oxygen = 95.1 g (1)

C $\frac{144}{12.01}$: H $\frac{12.01}{1.008}$: N $\frac{85.1}{14.01}$: O $\frac{95.1}{16}$

= 11.99 mol = 12.00 mol = 6.072 mol = 5.944 mol.

2 : 2 : 1 : 1 (1)

∴ C_2H_2NO (1)

(b) If one mole of uracil contains 28.02 g of nitrogen, calculate the molecular formula of this compound. **2**

$\frac{28.02}{14.01}$ = 2 mol (1)

∴ formula is $C_4H_4N_2O_2$ (1)

Question 22 (6 marks) **Marks**

The metal activity series can be experimentally derived using the reactions of metals with acids.

(a) Redox reactions involve the transfer of electrons. Use a balanced chemical equation and the relevant half equations to explain why the reaction of zinc with aqueous sulfuric acid can be considered to be a redox reaction. 3

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$ (1)

$Zn \rightarrow Zn^{2+} + 2e$

$2H^+ + 2e \rightarrow H_2$ (1)

Explanation – ∴ transfer of electrons (1)
OR oxidation of Zn & reduction of H^+

(b) Not all metals react with acids. Explain why some metals will react with an acid (such as aqueous sulfuric acid), whilst others will not. 3

* Basic description of reaction including examples of metals that will react and those which will not. (1)
* Discussion of the relative 'pull' of nucleus on the valence electrons (1)
* Relative pull of metal nucleus on electrons Vs pull of hydrogen nucleus on electrons & therefore ability of metal Vs react with acid (1)

BLANK PAGE

Master's initials

Name

Question 23 (2 marks) **Marks**

Mendeleev is universally acknowledged as having put together the first functioning Periodic Table. Outline two decisions he made which allowed him to succeed in putting together a functioning Periodic Table when others had failed.

Each work ① mark. need 2 right none wrong for 2 mks.

- Organised by mass AND reactivity/properties. 2
- properties and reactivity took preference so swapped some elements eg. Te & I
- left gaps for elements predicted to that he predicted were still to be found

Marks

Question 24 (5 marks)

The boiling points for Group V hydrides are shown in the table below.

Hydride	Boiling point (°C)
ammonia (NH_3)	-33
phosphine (PH_3)	-88
arsine (AsH_3)	-55
stibine (SbH_3)	-17
bismuthine (BiH_3)	22

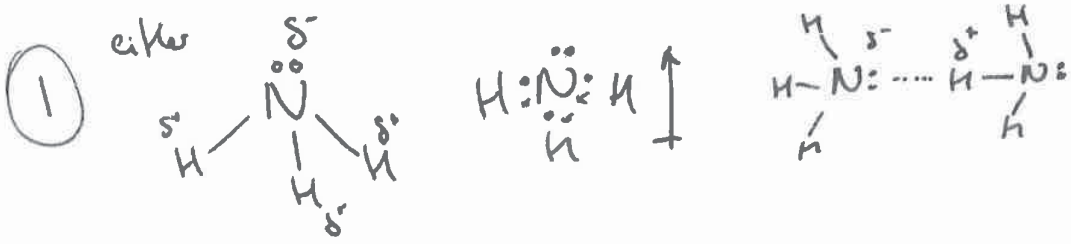
(a) Explain the general trend in boiling points observed for phosphine to bismuthine. **2**

• boiling point increases as mass increases or down the groups.

• As you go down mass + number of electrons increases ∴ dispersion forces increase.

(b) Using a diagram, explain why the boiling point of ammonia does not follow the same general trend as phosphine to bismuthine. **3**

either



(1)

(1) • Ammonia has hydrogen bonding which is caused by a highly polar bond due to a large difference in electronegativity.

(1) • hydrogen bonding much stronger than dipole-dipole or dispersion ∴ requires more energy to disrupt.

Question 25 (5 marks) **Marks**

At 25 °C, the maximum amount of sodium chloride that will dissolve in 100 mL of water is 35.9 g.

(a) What is the concentration (in mol L^{-1}) of a saturated solution of sodium chloride at 25 °C? 2

(1) $n = \frac{m}{fw}$ $n = \frac{35.9}{58.44} = 0.61430527$

(1) $C = \frac{n}{V} = \frac{0.61430527}{0.1} = 6.14 \text{ mol } L^{-1}$

(b) 25.0 mL of a saturated solution of sodium chloride is diluted to 300 mL. Calculate the concentration (in mol L^{-1}) of the final solution. 1

$C_1V_1 = C_2V_2$ $\therefore C_2 = \frac{C_1V_1}{V_2}$

as $n_1 = n_2$ $= \frac{6.14 \times 0.025}{0.3} = 0.512 \text{ mol } L^{-1}$

(c) 40.0 g of sodium chloride is added to 100 mL of deionised water at 25 °C. Using this solution as an example, describe the movement of solute particles in a saturated solution. 2

(1) Dynamic equilibrium.

(1) Rate of precipitation equals the rate of dissolution.

BLANK PAGE

CRIB
Master's initials
ETS
Name

Question 26 (4 marks) **Marks**

When 4.000 g of potassium hydroxide is dissolved in 100.00 g of water, the temperature of the water increases from 25.00 °C to 34.83 °C.

(a) Calculate the chemical amount of potassium hydroxide that was used. **1**

0.07129 mol

(b) Calculate the molar enthalpy of solution ($\Delta_{sol}H^{\circ}$, in kJ mol^{-1}) for potassium hydroxide. **3**

$q = m\,c\,\Delta T$

(1) $= 100\ g \times 4.18\ J\ g^{-1}\ K^{-1} \times 9.83\ K$

$= 4108.94\ J = 4.10894\ kJ$

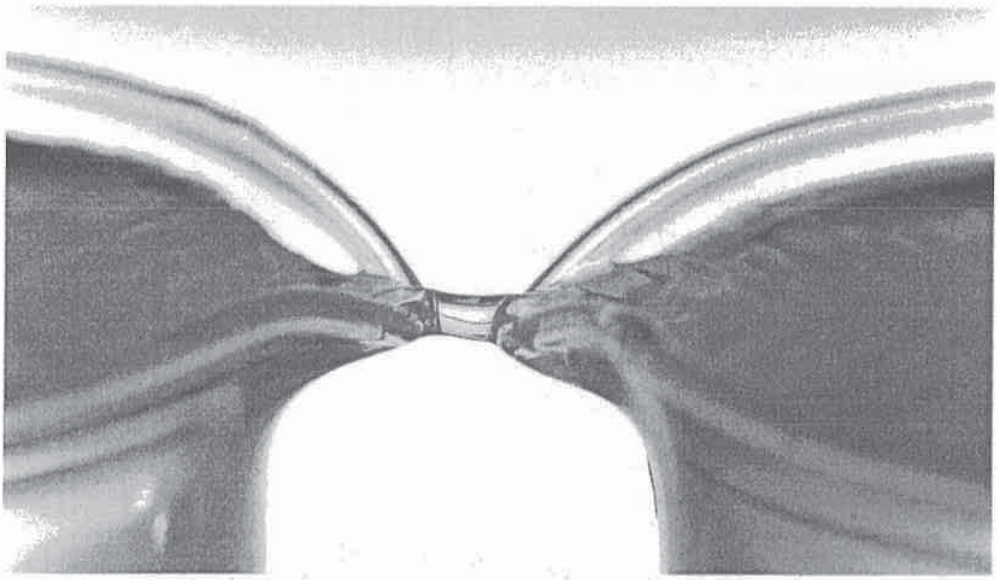
$\Delta H = \frac{-q}{n} = \frac{-4.10894\ kJ}{0.07129\ mol}$

(1) $= -56.73\ kJ\ mol^{-1}$

(1) sig figs (4)

Question 27 (3 marks) **Marks**

The image below shows a short "thread" of water suspended between two beakers.



Explain why it is possible to produce a stable "thread" of water as shown above.

3 marks – strong H-bonding between water molecules on surface have unbalanced forces → high S.T.
– requires more force to break thread to overcome tension / resists an increase in S.A. etc 3

2 marks – good discussion of strong intermolecular forces / cohesive forces, no link to how high S.T. ~~cause~~ allows thread

1 mark – no explanation, only unrelated statements.

Question 28 (2 marks)

A hydrocarbon will burn completely once its ignition temperature is reached, even though only a fraction of its molecules will have enough energy to react. Explain this observation.

(1) explanation of ignition temp

(1) exothermic combustion releases heat so more molecules have enough energy to overcome E_A. 2

Question 29 (3 marks)

Analyse the impact of increasing the temperature on reaction rate.

(1) more particles have K.E. > E_A

so ~~more~~ higher % successful collisions

(1) more KE so more collisions overall

(1) ∴ The effect of ↑T is ↑ rate. 3

BLANK PAGE

Master's initials

Name

Question 30 (6 marks) **Marks**

Carbon has a number of different allotropic forms, including diamond and graphite.

(a) Compare the nature and geometry of the bonding in diamond and graphite.

[Mark
1 mark
Note

Nature - diamond, localised covalent, graphite delocalised 2

Geometry - diamond tetrahedral, graphite - planar (trigon

Many boys launched into a discussion on structure.
If nothing else a mark given for identifying covalent bonds in common.

(b) Under the right conditions, graphite can be converted into diamond.

$$C_{graphite} \rightarrow C_{diamond} \quad \Delta H° = +2 \text{ kJ mol}^{-1}$$

The activation energy for this process is 120 kJ mol^{-1}.

(i) Outline why the activation energy for this process is so high.

The carbon-carbon bonds in graphite are very strong and require a lot of energy to break. 1

(ii) Given the above information, suggest what reaction conditions would be required to convert graphite into diamond.

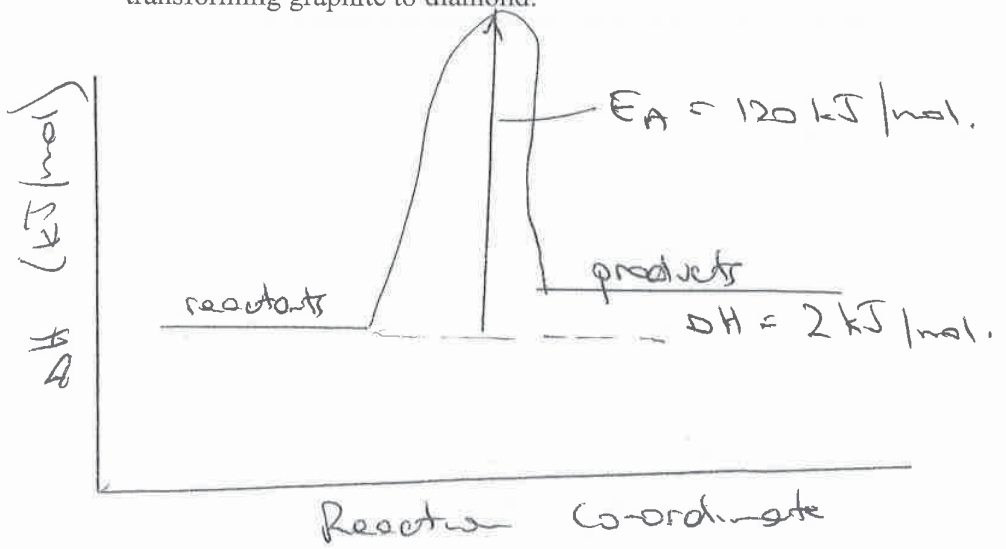
High temperature. 1

Question 30 continued on next page.

Question 30 continued.

Marks

(ii) Draw a fully labelled energy profile diagram for the reaction transforming graphite to diamond. **2**



Exothermic Reaction 0-marks.
If ΔH in diagram is more than 50% of E_A then only one mark awarded (maximum)

Question 31 (4 marks)

Describe a reliable experiment that you could perform in the laboratory, using magnesium and hydrochloric acid, to investigate the effect of changing concentration on reaction rate. Include the expected result of this experiment.

- Mg mass (surface area) kept constant. **4**
- Concentration of HCl varied.
- Identify Dependent variable to measure.
- Duplicate experiment to increase reliability
- Sensible expected result.

All present	4 marks
missing 1	3 marks
missing 2	2 marks
missing 3	1 mark

note. For validity (not required) the volumes of the HCl should vary so that moles HCl remains constant!! Rarely considered.

Question 32 (3 marks) **Marks**

A BBQ heat bead, comprised of a mixture of graphite and clay, was placed in a container. An excess of oxygen gas was passed over the heat bead as it was being combusted. The graphite underwent complete combustion, but the clay remained unchanged. Masses of the container and its contents were documented during the experiment along with the mass of CO_2 produced.

Determine the percentage by mass of graphite in the BBQ heat bead using the information in the table below.

Item	Mass (kg)
reaction container	2.45
reaction container with heat beads before combustion	3.75
evolved CO_2	2.89

3

1 Mark. moles CO_2 65.7 mol.

~~Mass~~ 1 Mark mass graphite: 788 g

1 Mark % graphite 60%.

ETS
Master's initials
cnb
Name

Question 33 (4 marks) **Marks**

The following information refers to the reactions of an unknown compound, Compound **Y**. Compound **Y** is a molecular gas composed of nitrogen and oxygen. All gas volumes are measured at 25 °C and 100 kPa. 4

- Compound **Y** can be prepared by the reaction of another gas, Compound **X**, with oxygen. In this reaction, 1.00 L of Compound **X** reacts with 0.500 L of oxygen to produce 1.00 L of Compound **Y**.

- Compound **Y** will react with lead(II) oxide to produce Compound **X** and a white solid, Compound **Z**. In this reaction, 3.00 g of lead(II) oxide will react with 1.00 L of Compound **Y**, to produce 4.45 g of Compound **Z** and 0.333 L of Compound **X**. Compound **Z** is soluble in water.

- Compound **Y** has the interesting property that it can be used as a source of oxygen to promote combustion reactions. For example, it can be used as the oxygen source for the complete combustion of hydrocarbons, so that oxygen gas does not need to be used.

Showing all necessary logic, write balanced chemical equations for the three chemical reactions below. Ensure you clearly identify the formulae of Compounds **X**, **Y** and **Z**;

a) The reaction of Compound **X** with oxygen to produce Compound **Y**.
b) The reaction of Compound **Y** with lead(II) oxide to produce Compound **Z** and Compound **X**.
c) The reaction of methane and Compound **Y**.

a) $2NO + O_2 \rightarrow 2NO_2$
X Y

b) $3NO_2 + PbO \rightarrow Pb(NO_3)_2 + NO$
Y X

c) $2NO_2 + CH_4 \rightarrow CO_2 + 2H_2O + N_2$

PTO

4 marks
- clear, logical process
- X, Y, Z clearly identified
- all equations correct
((c) complete combustion)

3 marks -
- as for 4 marks, but 1 error
e.g. not complete combustion
for (c)

2 marks
- at least one correct eq & an X/Y pair that matches data

or

- identifies Z and correct molar calcs

1 mark
- one equation that matches data

or

- correct molar calcs