SYDNEY GRAMMAR SCHOOL

2015
FORM V
HALF-YEARLY EXAMINATION
1:00pm 13 May 2015

Chemistry

Working time 2 Hours

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 the Multiple Choice Answer Sheet and the first page in Parts B to F

Collection

- **Remove central staple** and collect in ONE bundle
- Hand in **all** parts of the paper, including the multiple choice questions

Total marks (88)

This paper has six parts, Parts A to F

Part A
Total marks **(18)**
- Attempt ALL Questions
- Allow about 15 minutes for this Part.

Parts B to F
Total marks **(70)**
- 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	

5CY201 - AKBB	5CY202 - MRB	5CY203 - TW	5CY204 - ZI
5CY205 - EJS	5CY206 - CRMR	5CY207 - TW	

EXAMINERS: AKBB / CRMR / MRB / MTK/ TW

Part A

Total marks (18)
Attempt ALL Questions
Allow about 15 minutes for this Part

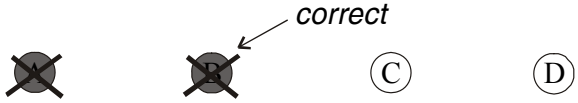
Use the multiple-choice Answer Sheet.

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

Sample 2 + 4 =

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 alternative most accurately lists metals in order of their discovery and use?

(A) aluminium, copper, iron, sodium
(B) silver, silicon, sodium, gold
(C) gold, copper, iron, aluminium
(D) silver, magnesium, gold, iron

2 Which of the following elements comprise a triad as observed by Döbereiner?

(A) Na, Mg, Al
(B) Ne, Ar ,Kr
(C) Mn, Fe, Co
(D) Cl, Br, I

3 2 L of an unknown gas has the same mass as 0.5 L of bromine gas at the same temperature and pressure. What is the gas?

(A) CO_2
(B) Ne_2
(C) F_2
(D) Ar

4 Moving from left to right across Period 3 of the Periodic Table, which of the following does **not** increase?

(A) The number of electron shells
(B) The total number of electrons
(C) The number of valence electrons
(D) The charge on the nucleus

5 Which of the following elements has the highest electronegativity?

(A) helium
(B) francium
(C) fluorine
(D) nitrogen

6 Which statements are correct for the alkali metals Li to Cs?

I Melting Point increases
II First ionisation energy decreases
III Ionic radius increases

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

7 Which of the following iron-containing minerals has the greatest percentage of iron by mass?

(A) magnetite, $Fe_3O_{4(s)}$
(B) hematite, $Fe_2O_{3(s)}$
(C) siderite, $FeCO_{3(s)}$
(D) goethite, $FeO(OH)_{(s)}$

8 Approximately how many atoms are there in 1.00 g of water?

(A) 3.34×10^{22}
(B) 1.00×10^{23}
(C) 6.02×10^{23}
(D) 1.81×10^{24}

9 Which of the following substances has the **smallest** molar mass?

(A) sodium oxide
(B) magnesium oxide
(C) potassium oxide
(D) calcium oxide

10 When comparing a more reactive metal with a less reactive metal:

(A) The less reactive metal is more likely to be found as an uncombined naturally occurring element.
(B) The more reactive metal is more spontaneous in losing electrons than is the less reactive metal.
(C) More energy is required to extract the less reactive metal from one of its compounds.
(D) More reactive metals absorb more heat than less reactive metals when they react.

11 What is the electrolysis of water?

(A) A physical process that separates hydrogen and oxygen molecules from water molecules.
(B) A physical process that weakens intermolecular forces releasing hydrogen and oxygen atoms.
(C) A chemical process that weakens intermolecular forces allowing the more volatile oxygen and hydrogen molecules to boil off.
(D) A chemical process that breaks covalent bonds within water molecules producing hydrogen and oxygen molecules.

12 Nitrogen trifluoride can be decomposed to form nitrogen and fluorine gas. Which of the following balanced equations correctly represents this reaction?

(A) $NF_{3(g)} \rightarrow N_{(g)} + F_{3(g)}$
(B) $2N_3F_{3(g)} \rightarrow 3N_2F_{2(g)}$
(C) $2NF_{3(g)} \rightarrow N_{2(g)} + 3F_{2(g)}$
(D) $NF_{3(g)} \rightarrow N_{(g)} + 3F_{(g)}$

13 Which of the following shows elements in increasing atomic mass?

(A) Cl, Ar, K, Ca,
(B) Zn, Cu, Ni, Co
(C) Cs, Rb, K, Na
(D) I, Te, Xe, Cs

14 In which of the following substances do strong chemical bonds **NOT** extend throughout the crystal lattice in the **solid** state?

(A) mercury
(B) iodine
(C) silicon dioxide
(D) sodium chloride

15 Using the solubility rules, determine which of the following combinations of solutions would form a precipitate.

(A) Magnesium sulfate and barium nitrate
(B) Barium chloride and sodium hydroxide
(C) Sodium carbonate and lithium nitrate
(D) Silver nitrate and potassium nitrate

16 Which of the following contains the same number of ions as 1 mole of aluminium chloride?

(A) 3 mole of sodium hydroxide
(B) 2 mole of barium carbonate
(C) 1 mole of ammonium nitrate
(D) 0.5 mole of ammonium sulfate

17 Consider the following atom, $^{17}_{8}O$. This atom contains:

(A) 8 protons, 8 electrons and 17 neutrons.
(B) 8 protons, 8 electrons and 9 neutrons.
(C) 9 protons, 9 electrons and 17 neutrons.
(D) 17 protons, 17 electrons and 8 neutrons.

18 Which of the following is the correct IUPAC name for FeP?

(A) iron monophosphide
(B) iron monophosphate
(C) iron(III) phosphide
(D) iron(III) phosphate

Master's initials

Name

Part B

Total marks (19)
Attempt ALL Questions
Write your name and your Master's initials in the space provided above.

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

Question 19 (3 marks) **Marks**

Complete the following table.

Alloy	Use	Property related to use
Brass		
	Joining metals together	
		High tensile strength

3

Question 20 (3 marks)

Complete the table below, identifying from everyday life examples where heat, light and electricity are involved in chemical reactions. Indicate also whether the energy is released or absorbed by circling the appropriate response.

Energy type	Example of Everyday Reaction	Energy absorbed or released
Electricity		absorbed/released
Heat		absorbed/released
Light		absorbed/released

3

Question 21 (3 marks) **Marks**

Write balanced chemical equations for the following reactions, including states:

(a) Magnesium oxide with hydrochloric acid.

_____ **1**

(b) Sodium hydrogen carbonate with sulfuric acid.

_____ **1**

(c) Sodium with water.

_____ **1**

Question 22 (3 marks)

Pentane and water are immiscible liquids that have the properties below.

	Boiling Point (^oC)	**Density (g cm^{-3})**
Pentane	36	0.6
Water	100	1.0

Assess the relative suitability of distillation or a separating funnel as techniques to separate pentane and water. **3**

_____

_____

_____

_____

_____

_____

_____

_____

Master's initials

Name

Marks

Question 23 (3 marks)

Complete the following table.

Name of Element or Ion	Protons	Charge	Electron Configuration
	12		2.8
Phosphorus		0	
		$^{-}1$	2.8.8

3

Question 24 (4 marks)

Draw Lewis electron dot diagrams for the following materials.

H_2	O_2
H_2O	OH^-

4

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Master's initials

Name

Part C

Total marks (18)
Attempt ALL Questions
Write your name and your Master's initials in the space provided above.

Question 25 (3 marks) **Marks**

A sample of processed meat was placed in a container of known mass and dried in an oven until the mass no longer reduced. The various masses were recorded in the table below.

Item	Mass (g)
Container	21.3
Container and undried meat sample	24.2
Container and dried meat sample	23.4

Determine the percentage water by mass in the original sample of processed meat.

3

Question 26 (3 marks)

(a) Write a balanced equation for the reaction of aluminium with sulfuric acid.

1

(b) Write and identify the reduction and oxidation half equations for the reaction of aluminium with sulfuric acid.

Reduction: **2**

Oxidation:

Question 27 (4 marks) **Marks**

Potassium is ductile while potassium chloride is brittle. Explain the difference in these properties in terms of the structure and bonding of the two materials.

4

Question 28 (2 marks)

A pupil was given three metal samples (lead, silver and magnesium), but they forgot to label the samples. The pupil then conducted the following tests.

Metal	**Reaction with H_2O**	**Reaction with acid**	**Reaction with oxygen**
1	No Visible Reaction	No Visible Reaction	No Visible Reaction
2	White coating formed in near-boiling water	Reacted vigorously with cold H_2SO_4	Burned readily as a thin foil
3	No Visible Reaction	Reacted slowly with warm H_2SO_4	Formed a red/brown layer when heated in air

Identify the metals 1, 2 and 3.

Metal 1: _____ **2**

Metal 2: _____

Metal 3: _____

Master's initials

Name

Question 29 (6 marks) **Marks**

Five **consecutive** elements in increasing atomic number have **first** ionisation energies as shown in the table below.

Element	W	V	X	Y	Z
First ionisation energy (kJ / mol)	1260	1520	418	590	632

(a) Define First Ionisation Energy

_____ **1**

_____

(b) Identify which element/(s) (W-Z) would be most likely to:

(i) be a noble gas.

_____ **1**

(ii) form an ion with a 1+ charge.

_____ **1**

(iii) be metals.

_____ **1**

(iv) exist as a diatomic molecule.

_____ **1**

(v) react most vigorously with dilute hydrochloric acid.

_____ **1**

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Master's initials

Name

Part D

Total marks (15)
Attempt ALL Questions
Write your name and your Master's initials in the space provided above.

Question 30 (4 marks) **Marks**

Explain why atomic radii decrease as you move along a Period of the Periodic Table but increase as you move down a Group.

4

Question 31 (3 marks)

Complete the table below by using the physical properties in the table to classify the following elements as metals, non-metals or semi-metals and solids, liquids or gases.

	Melting Point (^oC)	**Boiling Point (^oC)**	**Density ($g\ cm^{-3}$)**	**Electrical conductivity ($MS\ m^{-1}$)**	**Metal/Non-metal/Semi-metal**	**Solid/Liquid/ Gas at 300^oC**
A	63	760	0.86	14		
B	44	280	1.82	10^{-15}		
C	-39	357	13.5	1.0		
D	937	2830	5.3	10^{-4}		

3

Question 32 (5 marks) **Marks**

A 31.08 g sample of lead was placed into a 100 mL solution containing 16.99 g silver nitrate and left until the reaction had gone to completion.

Complete the table. Show relevant calculations in the space below the table.

Chemical species	$Pb^{2+}_{(aq)}$	$Pb_{(s)}$	$Ag^{+}_{(aq)}$	$Ag_{(s)}$	$NO_3^{-}{}_{(aq)}$
Moles in final mixture					
Balanced chemical equation					

5

Master's initials

Question 33 (3 marks) **Marks**

Name

In 1813, shortly after Gay-Lussac published his "Memoir on the Combination of Gaseous Substances with Each Other", Jöns Jacob Berzelius published an account of 2 volumes of ammonia reacting with 2 volumes of oxygen to produce 3 volumes of water vapour and 1 volume of phlogisticated nitrous air.

(a) Write a balanced chemical equation for this reaction.

2

(b) What is the IUPAC name for phlogisticated nitrous air?

1

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Master's initials

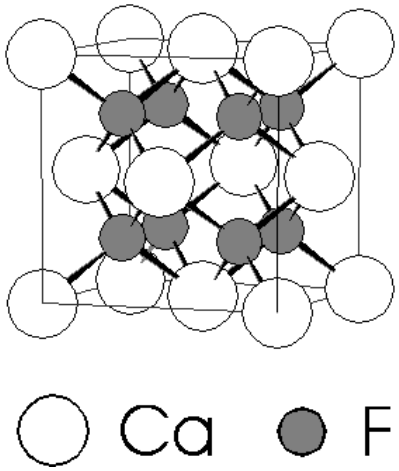
Name

Part E

Total marks (3)
Attempt ALL Questions
Write your name and your Master's initials in the space provided above.

Question 34 (3 marks) **Marks**

Discuss the advantages and limitations of the below model of calcite, CaF_2.



3

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Master's initials

Name

Part F

Total marks (15)
Attempt ALL Questions
Write your name and your Master's initials in the space provided above.

Question 35 (7 marks) **Marks**

Chromium is often found in the Earth's crust as chromite, $FeCr_2O_4$. The production of chromium metal from chromite involves a series of chemical reactions:

$4\ FeCr_2O_{4(s)} + 8\ Na_2CO_{3(s)} + 7\ O_{2(g)} \rightarrow 8\ Na_2CrO_{4(s)} + 2\ Fe_2O_{3(s)} + 8\ CO_{2(g)}$

$2\ Na_2CrO_{4(s)} + H_2SO_{4(aq)} \rightarrow Na_2Cr_2O_{7(s)} + Na_2SO_{4(aq)} + H_2O_{(l)}$

$Na_2Cr_2O_{7(s)} + 2\ C_{(s)} \rightarrow Cr_2O_{3(s)} + Na_2CO_{3(s)} + CO_{(g)}$

$Cr_2O_{3(s)} + 2\ Al_{(s)} \rightarrow Al_2O_{3(s)} + 2\ Cr_{(s)}$

A 210.0 g ore sample containing 75.40% chromite by mass is processed through this series of chemical reactions.

(a) Calculate the mass of chromite, $FeCr_2O_4$, present in the 210.0 g ore sample. **1**

(b) Calculate the mass of carbon dioxide gas produced when chromium is produced from the 210.0 g ore sample by this process. **3**

Question 35 continued on next page.

Question 35 continued. **Marks**

(c) Calculate the mass of chromium metal produced in this process using the 210.0 g sample.

2

(d) Calculate the number of aluminium atoms consumed in this process.

1

Question 36 (3 marks)

In 1962, the synthesis of the first binary compound of a noble gas was reported in the Journal of the American Chemical Society. Decomposition of this colourless solid compound was reported to give rise to 0.2507 g xenon and 0.1435 g fluorine by mass. Calculate the empirical formula of this compound.

3

Master's initials

Name

Marks

Question 37 (5 marks)

Wegscheiderite is an evaporite mineral found at the Green River Formation in Wyoming, USA. Elemental analysis shows wegscheiderite to contain four different elements. When 10.000 g of wegscheiderite is treated with excess hydrochloric acid, 4.917 g of carbon dioxide is given off. In a separate experiment, 0.1000 g of wegscheiderite is dissolved in water and treated with a solution of uranyl zinc acetate. A precipitate of $(UO_2)_3ZnNa(CH_3COO)_9 \cdot 6H_2O$ with a molar mass 1537.9 g mol^{-1} is produced which after purification has a mass of 2.148 g.

Calculate the empirical formula of wegscheiderite, showing all working and logic.

5

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Master's initials

Name

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) …… 22.71 L

at 25 °C (298K) …… 24.79 L

Ionisation constant for water at 25°C (298 K), K_w …… 1.0×10^{-14}

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

Some useful formulae

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

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
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

Master's initials

CRB

Name

CHEMISTRY
PART A
ANSWER SHEET

2015
FORM V
MAY EXAMINATION
Wed 13th May 1.00 pm

General Instructions

- Write your Master's initials and Name in the space provided.
- Attempt all questions 1 – 18
- 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.

1.	A	B	●	D
2.	A	B	C	●
3.	A	B	C	●
4.	●	B	C	D
5.	A	B	●	D
6.	A	B	●	D
7.	●	B	C	D
8.	A	●	C	D
9.	A	●	C	D
10.	●	B	C	D
11.	A	B	C	●
12.	A	B	●	D
13.	A	B	C	●
14.	A	●	C	D
15.	●	B	C	D
16.	A	●	C	D
17.	A	●	C	D
18.	A	B	●	D

Master's initials

Name

Part B
Total marks (19)
Attempt ALL Questions
Write your name and your Master's initials in the space provided above.

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

Question 19 (3 marks) **Marks**

Complete the following table.

Alloy	Use	Property related to use
Brass	- Jewellery - instruments - machine parts etc.	- hard - malleable - sonorous/resonates - gold colour
Solder	Joining metals together	- low melting point - sticks well to other metals - malleable when heated.
Steel or Bronze	steel = construction - building etc. Bronze = weapons.	High tensile strength

3

Question 20 (3 marks)

Complete the table below, identifying from everyday life examples where heat, light and electricity are involved in chemical reactions. Indicate also whether the energy is released or absorbed by circling the appropriate response.

Energy type	Example of Everyday Reaction	Energy absorbed or released
Electricity	battery electrolysis	absorbed/released
Heat	fire, gas stove	absorbed/released
Light	photosynthesis glow sticks	absorbed/released

had to have an everyday use
if stated just electrolysis - mark not given

3

for one mark - example and energy both correct.

Question 21 (3 marks) **Marks**

Write balanced chemical equations for the following reactions, including states:
One states mistake allowable if incorrect state given

(a) Magnesium oxide with hydrochloric acid.

$MgO_{(s)} + 2HCl_{(aq)} \rightarrow MgCl_{2(aq)} + H_{2(g)}$ **1**

(b) Sodium hydrogen carbonate with sulfuric acid.

$2NaHCO_{3(s)} + H_2SO_{4(aq)} \rightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)} + 2CO_{2(g)}$ **1**
or (aq)

(c) Sodium with water.

$2Na_{(s)} + 2H_2O_{(l)} \rightarrow 2NaOH_{(aq)} + H_{2(g)}$ **1**

↑ many said this formed Na_2O.

Question 22 (3 marks)

Pentane and water are immiscible liquids that have the properties below.

	Boiling Point (°C)	Density (g cm^{-3})
Pentane	36	0.6
Water	100	1.0

Assess the relative suitability of distillation or a separating funnel as techniques to separate pentane and water.

Unless negated by an incorrect fact

e.g. densities too close.

① = Why separating funnel would work **3**

① = Why distillation would work

① = assessment statement.

- Separating or distillation or both but a reason.

Overall wholistically marked.

Master's initials

Name

Marks

Question 23 (3 marks)

Complete the following table.

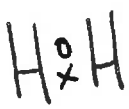
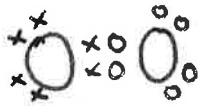
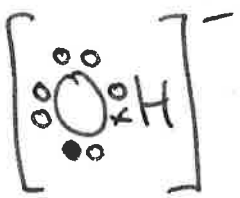
Name of Element or Ion	Protons	Charge	Electron Configuration
Magnesium	12	+2	2.8
Phosphorus	15	0	2.8.5
chlorine ion or chloride	17	-1	2.8.8

bright - 3marks
4-5 right = 2 marks
2-3 right = 1 marks
0-1 right = 0 marks

3

Question 24 (4 marks)

Draw Lewis electron dot diagrams for the following materials.

H_2 	O_2 
H_2O 	OH^- 

- Boys should make certain electrons are clear and paired.
- Many had Hero atoms too far apart.

4

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AUKS
Master's initials

Name

Part C

Total marks (18)
Attempt ALL Questions
Write your name and your Master's initials in the space provided above.

Question 25 (3 marks) **Marks**

A sample of processed meat was placed in a container of known mass and dried in an oven until the mass no longer reduced. The various masses were recorded in the table below.

Item	Mass (g)
Container	21.3
Container and undried meat sample	24.2
Container and dried meat sample	23.4

Determine the percentage water by mass in the original sample of processed meat.

$24.2 - 23.4 = 0.8$ g of Water (1)

$24.2 - 21.3 = 2.9$ g of undried meat (1)

$\frac{0.8}{2.9} \times 100 = 27.6\ \%$ (1)

3

Question 26 (3 marks)

(a) Write a balanced equation for the reaction of aluminium with sulfuric acid.

$2Al + 3H_2SO_4 \rightarrow Al_2(SO_4)_3 + 3H_2$

States not required.

1

(b) Write and identify the reduction and oxidation half equations for the reaction of aluminium with sulfuric acid.

Reduction: $2H^+ + 2e \rightarrow H_2$

Oxidation: $Al \rightarrow Al^{3+} + 3e$

2

Question 27 (4 marks) **Marks**

Potassium is ductile while potassium chloride is brittle. Explain the difference in these properties in terms of the structure and bonding of the two materials.

* K is a metal made of a 3D lattice of cations in a sea of delocalised electrons MS
* When a metallic structure is distorted the cations are moved, & so the electrons flow in order to neutralise/stabilise the structure → ductile. EF
* KCl – is an ionic lattice of alternating cations & anions. 1S
* As you distort the structure the cations align with cations & the anions with anions, & thus repel 1R

Marked holistically

4

Question 28 (2 marks) → Brittle

A pupil was given three metal samples (lead, silver and magnesium), but they forgot to label the samples. The pupil then conducted the following tests.

Metal	Reaction with H_2O	Reaction with acid	Reaction with oxygen
1	No Visible Reaction	No Visible Reaction	No Visible Reaction
2	White coating formed in near-boiling water	Reacted vigorously with cold H_2SO_4	Burned readily as a thin foil
3	No Visible Reaction	Reacted slowly with warm H_2SO_4	Formed a red/brown layer when heated in air

Identify the metals 1, 2 and 3.

Metal 1: Silver

Metal 2: Magnesium

Metal 3: Lead.

2

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Name

Question 29 (6 marks) **Marks**

Five **consecutive** elements in increasing atomic number have **first** ionisation energies as shown in the table below.

Element	W	V	X	Y	Z
First ionisation energy (kJ / mol)	1260	1520	418	590	632

(a) Define First Ionisation Energy

The amount of energy (per mole) required to remove an electron from an atom. (in the gaseous state) 1

(b) Identify which element/(s) (W-Z) would be most likely to:

(i) be a noble gas.

V 1

(ii) form an ion with a 1+ charge.

X 1

(iii) be metals.

X + Y + Z 1

(iv) exist as a diatomic molecule.

W 1

(v) react most vigorously with dilute hydrochloric acid.

X 1

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Part D

Total marks (15)
Attempt ALL Questions
Write your name and your Master's initials in the space provided above.

Question 30 (4 marks) **Marks**

Explain why atomic radii decrease as you move along a Period of the Periodic Table but increase as you move down a Group.

Marks	Description
4	• Discusses that across a period: increased numbers of electrons go into same shell; more protons yet same shielding; hence smaller radius. • Discusses that down group; new shell; even though more protons and electrons, also more electron shielding from inner shell electrons, hence larger radius, • Gives logical, clear progression and uses good scientific language.
3	• As per 4 marks, but with one item incorrect / missing
2	• Provides 2 items listed for 1 mark
1	• Mentions any chemistry principle correctly from 4 marks list.

Question 31 (3 marks)

Complete the table below by using the physical properties in the table to classify the following elements as metals, non-metals or semi-metals and solids, liquids or gases.

	Melting Point (°C)	Boiling Point (°C)	Density (g cm^{-3})	Electrical conductivity (MS m^{-1})	Metal/Non-metal/Semi-metal	Solid/Liquid/ Gas at 300°C
A	63	760	0.86	14	*M*	*L*
B	44	280	1.82	10^{-15}	*NM*	*G*
C	-39	357	13.5	1.0	*SM or M*	*L*
D	937	2830	5.3	10^{-4}	*SM*	*S*

<4 – 0 mark
4-5 – 1 mark
6-7 – 2 marks
8 – 3 marks

Question 32 (5 marks) **Marks**

A 31.08 g sample of lead was placed into a 100 mL solution containing 16.99 g silver nitrate and left until the reaction had gone to completion.

Complete the table. Show relevant calculations in the space below the table.

Chemical species	$Pb^{2+}_{(aq)}$	$Pb_{(s)}$	$Ag^{+}_{(aq)}$	$Ag_{(s)}$	$NO_3^{-}{}_{(aq)}$
Moles in final mixture	*0.05*	*0.10*	*0*	*0.10*	*0.10*

Equation $Pb_{(s)} + 2\ AgNO_{3\ (aq)} \rightarrow 2\ Ag_{(s)} + Pb(NO_3)_{2\ (aq)}$

Working
Initial values:
$n(Pb) = 31.08 / 207.2 = 0.15$ *moles*
$n(AgNO_3) = 16.99 / (107.9 + 14.01 + 3 \times 16) = 0.099994$ *or* 0.10 *moles*
From equation, $AgNO_3$ *is limiting as lead would require 0.3 moles.*

Therefore after complete reaction:
$n(Ag^+) = 0$
As nitrate is spectator: 0.10 moles before and after.

From equation:
$n(Ag)$ = initial $n(Ag^+) = 0.10$ *moles*
$n(Pb^{2+}) = ½ \times n(Ag^+) = 0.05$ *moles*
$n(Pb) = 0.15 - ½ \times n(Ag^+) = 0.15 - 0.05 = 0.10$ *moles*

OR:

	$Pb_{(s)}$	Ag^+	Ag	Pb^{2+}	NO_3
Initial	*0.15*	*0.10*	*0*	*0*	*0.10*
Change	*-0.05*	*-0.10*	*+0.10*	*+0.05*	*0*
End	*0.10*	*0*	*0.10*	*0.05*	*0.10*

NOTE: Ticks do not equal marks

Marks	Description
5	• Calculates initial moles of lead as 0.15 and silver nitrate as 0.1 (or 0.09999) • Provides a correct balanced chemical equation • Determines that silver nitrate is the limiting reactant and sets Ag^+ to zero. • Recognises that nitrates are spectator ions and sets final concentration to 0.1 • Calculates $Pb_{(s)}$, Pb^{2+} and $Ag_{(s)}$ correctly showing full, well set-out working.

4	• As per 5 marks, but with one item incorrect / missing. (Clear setting out must allow error to be tracked.)
3	• Calculates initial moles of lead as 0.15 and silver nitrate as 0.1 (or 0.09999) • Provides a correct balanced chemical equation • Determines that silver nitrate is the limiting reactant and sets Ag^+ to zero. OR • Recognises that nitrates are spectator ions and sets final concentration to 0.1 OR • Provides working that can be followed to allow CE (carry error) marks.
2	• Provides 2 items listed for 1 mark
1	• Calculates initial moles of lead as 0.15 OR • Calculates silver nitrate as 0.1 (or 0.09999) OR • Provides a correct balanced chemical equation OR • Determines that silver nitrate is the limiting reactant and sets Ag^+ to zero.

Question 33 (3 marks) **Marks**

In 1813, shortly after Gay-Lussac published his "Memoir on the Combination of Gaseous Substances with Each Other", Jöns Jacob Berzelius published an account of 2 volumes of ammonia reacting with 2 volumes of oxygen to produce 3 volumes of water vapour and 1 volume of phlogisticated nitrous air.

(a) Write a balanced chemical equation for this reaction.

$2\,NH_{3\,(g)} + 2O_{2\,(g)} \rightarrow 3\,H_2O_{\,(g)} + N_2O_{\,(g)}$ **2**

2 marks – correct balanced equation

1 mark – recognises that gas volumes relate to molar quantities and writes a balanced chemical equation with the relevant molar quantities.

(b) What is the IUPAC name for phlogisticated nitrous air?

Dinitrogen monoxide - or CE from part (a) **1**

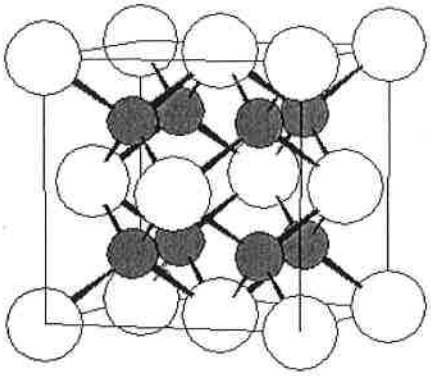
Master's initials

Name

Part E
Total marks (3)
Attempt ALL Questions
Write your name and your Master's initials in the space provided above.

Question 34 (3 marks) **Marks**

Discuss the advantages and limitations of the below model of calcite, CaF_2.



○ Ca ● F

Disadvantage.

1 Mark. Ions not indicated on ionic compound. 3

2 Marks An additional advantage and disadvantage.

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Master's initials

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Name

Part F

Total marks (15)
Attempt ALL Questions
Write your name and your Master's initials in the space provided above.

Question 35 (7 marks) **Marks**

Chromium is often found in the Earth's crust as chromite, $FeCr_2O_4$. The production of chromium metal from chromite involves a series of chemical reactions:

$4\ FeCr_2O_{4(s)} + 8\ Na_2CO_{3(s)} + 7\ O_{2(g)} \rightarrow 8\ Na_2CrO_{4(s)} + 2\ Fe_2O_{3(s)} + 8\ CO_{2(g)}$

$2\ Na_2CrO_{4(s)} + H_2SO_{4(aq)} \rightarrow Na_2Cr_2O_{7(s)} + Na_2SO_{4(aq)} + H_2O_{(l)}$

$Na_2Cr_2O_{7(s)} + 2\ C_{(s)} \rightarrow Cr_2O_{3(s)} + Na_2CO_{3(s)} + CO_{(g)}$

$Cr_2O_{3(s)} + 2\ Al_{(s)} \rightarrow Al_2O_{3(s)} + 2\ Cr_{(s)}$

A 210.0 g ore sample containing 75.40% chromite by mass is processed through this series of chemical reactions.

(a) Calculate the mass of chromite, $FeCr_2O_4$, present in the 210.0 g ore sample.

$m(FeCr_2O_4) = 210.0\,g \times \frac{75.40}{100.0} = 158.3\,g$ 1

(b) Calculate the mass of carbon dioxide gas produced when chromium is produced from the 210.0 g ore sample by this process.

$n(FeCr_2O_4) = \frac{158.3\,g}{223.85\,g\,mol^{-1}} = 0.7073\,mol$ (1)

$\therefore n(CO_2) = 1.415\,mol$ (1)

$\therefore m(CO_2) = 1.415\,mol \times 44.01\,g\,mol^{-1}$

$= 62.26\,g$ (1) 3

Question 35 continued on next page.

Question 35 continued. **Marks**

(c) Calculate the mass of chromium metal produced in this process using the 210.0 g sample.

$m(Cr) = 158.3\,g \times \frac{2 \times 52.00}{223.85} = 73.56\,g$ **2**

OR

$n(Cr) = 2\,n(FeCr_2O_4) = 1.415\,mol$ (1)

$\therefore m(Cr) = 1.415\,mol \times 52.00\,g\,mol^{-1} = 73.56\,g$ (1)

(d) Calculate the number of aluminium atoms consumed in this process.

$n(Al) = 1.415\,mol$ **1**

$\therefore$ # Al atoms $= 1.415\,mol \times 6.022 \times 10^{23}\,mol^{-1}$

$= 8.519 \times 10^{23}$.

Question 36 (3 marks)

In 1962, the synthesis of the first binary compound of a noble gas was reported in the Journal of the American Chemical Society. Decomposition of this colourless solid compound was reported to be give rise to 0.2507 g xenon and 0.1435 g fluorine by mass. Calculate the empirical formula of this compound.

$n(Xe) = \frac{0.2507\,g}{131.3\,g\,mol^{-1}} = 1.909 \times 10^{-3}\,mol$ (1) **3**

either $n(F) = \frac{0.1435\,g}{19.00\,g\,mol^{-1}} = 7.553 \times 10^{-3}\,mol$ (1)

$n(F_2) = \frac{0.1435\,g}{38.00\,g\,mol^{-1}} = 3.776 \times 10^{-3}\,mol$

Then $\frac{n(F)}{n(Xe)} = 3.956$ or $\frac{n(F_2)}{n(Xe)} = 1.978$

i.e. $XeF_{4(s)}$. (1)

Master's initials

Name

Marks

Question 37 (5 marks)

Wegscheiderite is an evaporite mineral found at the Green River Formation in Wyoming, USA. Elemental analysis shows wegscheiderite to contain four different elements. When 10.000 g of wegscheiderite is treated with excess hydrochloric acid, 4.917 g of carbon dioxide is given off. In a separate experiment, 0.1000 g of wegscheiderite is dissolved in water and treated with a solution of uranyl zinc acetate. A precipitate of $(UO_2)_3ZnNa(CH_3COO)_9 \cdot 6H_2O$ with a molar mass 1537.9, is produced which upon filtration and drying has a mass of 2.148 g.

Calculate the empirical formula of wegscheiderite, showing all working and logic.

5

$n(CO_2) = \frac{4.917\ g}{44.01\ g\,mol^{-1}} = 0.1117\ mol$

$n((UO_2)_3ZnNa(CH_3COO)_9 \cdot 6H_2O) = \frac{2.148\ g}{1537.9\ g\,mol^{-1}} = 1.397 \times 10^{-3}\ mol$

$\therefore n(Na^+ \text{ in } 0.1\ g \text{ Wegscheiderite}) = 1.397 \times 10^{-3}\ mol$

$\therefore n(Na^+ \text{ in } 10\ g \text{ Wegscheiderite}) = 0.1397\ mol.$

$\therefore \frac{n(Na^+ \text{ in } 10\ g \text{ Wegscheiderite})}{n(CO_2 \text{ from } 10\ g \text{ Wegscheiderite})} = \frac{0.1397\ mol}{0.1117\ mol} = 1.250.$

This suggests $5Na^+ : 4CO_2$.

The CO_2 comes from CO_3^{2-} or HCO_3^- reacting with acid.

To balance charges, need $3 \times HCO_3^-$ & $1 CO_3^{2-}$ for $5Na^+$.

This can and should be checked / derived from mass data:

In 10 g Wegscheiderite, $m(Na) = 0.1397\ mol \times 22.99\ g\,mol^{-1}$

$= 3.211\ g$

$m(\text{"}CO_3\text{"} \rightarrow \text{from } CO_3^{2-} \text{ or } HCO_3^-) = n(CO_2) \times (12.01 + 3 \times 16.00)$

$= 6.705\ g$

$\therefore m(\text{remaining}) = 10.000\ g - 9.916\ g = 0.0844\ g.$

Such a small mass is consistent with H; $n(H) = \frac{0.0844\ g}{1.008\ g\,mol^{-1}}$

$= 0.0837\ mol$

So $n(Na) : n(C) : n(O) : n(H) \rightarrow 5 : 4 : 8 : 3$

i.e. $Na_5(HCO_3)_3CO_3(s)$.

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