

Greenhead College

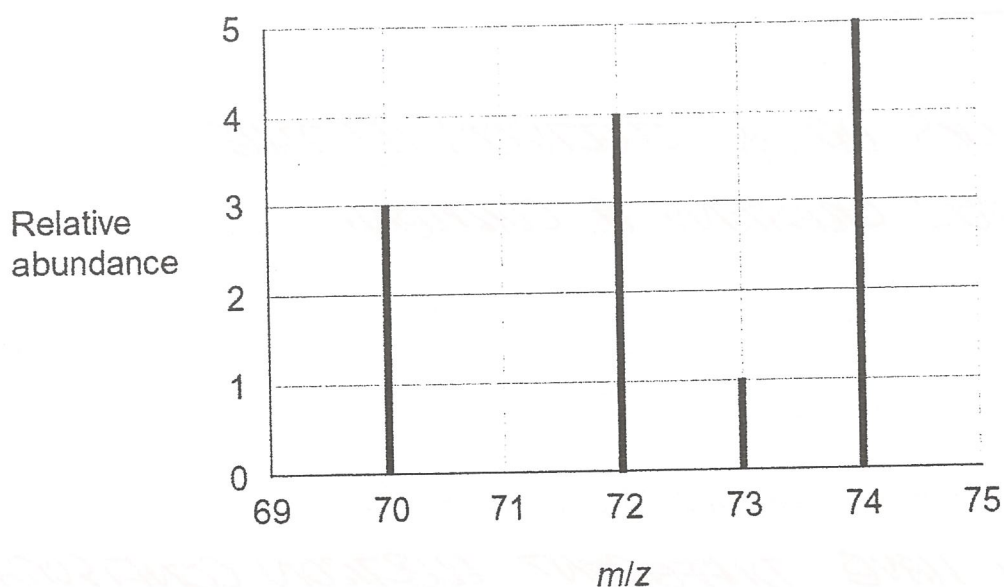
Paper 1C

Inorganic and Physical Chemistry

The maximum mark for this paper is 80

Name:

1. The mass spectrum of the isotopes of element X is shown in the diagram.



- (a) Define the term *relative atomic mass*.

S.A. *MEAN MASS OF AN ATOM OF AN ELEMENT
COMPARED TO $\frac{1}{12}$ of ^{12}C*

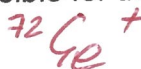
(2 marks)

- (b) Use data from the diagram to calculate the relative atomic mass of X.
Give your answer to one decimal place

$$\begin{aligned} \text{RAM} &= \frac{(3 \times 70) + (4 \times 72) + (1 \times 73) + (5 \times 74)}{13} \\ &= \frac{941}{13} \\ &= 72.4 \end{aligned}$$

(2 marks)

- (c) Identify the ion responsible for the peak at 72.



(1 mark)

- (d) In a mass spectrometer, the relative abundance of each isotope is proportional to the current generated by that isotope at the detector.

Explain how this current is generated.

S.A.

ION PICKS UP AN ELECTRON AT THE
DETECTOR CREATING A CURRENT

(1 mark)

- (e) X and Zn are different elements.

Explain why the chemical properties of ^{70}X and ^{70}Zn are different.

S.A.

THEY HAVE DIFFERENT ELECTRON CONFIGURATIONS

(1 mark)

2. A laboratory technician discovered four badly-labelled bottles, each containing one pure white solid. Each bottle contained a compound of a different Group 2 metal (magnesium, calcium, strontium and barium).

Some tests were carried out on the solids or if the compound was soluble, on the aqueous solution. The results are given in **Table 1**.

Table 1

Test	Compound 1	Compound 2	Compound 3	Compound 4
Added to water	Dissolves	Insoluble	Dissolves	Insoluble
Solution or solid added to HCl(aq)	Solution remains colourless	Gives off carbon dioxide gas and a colourless solution forms	Solution remains colourless	Solution remains colourless and heat released
Solution or solid added to NaOH(aq)	Solution gives a white precipitate	Solid remains insoluble	Solution gives a slight white precipitate	Solution has no visible change
Solution or solid added to H ₂ SO ₄ (aq)	Solution has no visible change	Gives off carbon dioxide gas and a white solid remains	Solution slowly forms a slight white precipitate	Solution forms a white precipitate

- (a) One of the bottles has a very faint label that could be read as 'Magnesium sulfate'.

Use the information in **Table 1** to deduce which **one** of the four compounds is magnesium sulfate and explain your answer.

Compound Compound 1 ✓

Explanation NO CHANGE WITH H₂SO₄ (ALREADY A SULFATE) ✓
Mg(OH)₂ INSOLUBLE ∴ WHITE PPT WITH NaOH ✓

(3 marks)

(b) The bottle containing **compound 2** has a 'Toxic' hazard symbol.

Use the information in **Table 1** to identify **compound 2**.

Explain both observations in the reaction with $\text{H}_2\text{SO}_4(\text{aq})$

Identity of **Compound 2** BARIUM CARBONATE ✓

Explanation CO_2 RELEASED $\therefore$ MUST BE CARBONATE ✓

..... WHITE PPT $\therefore$ BaSO_4 MUST BE FORMED ✓

(3 marks)

(c) Identify the compound that is strontium hydroxide.

Give an equation for the reaction of strontium hydroxide with sulfuric acid.

Compound COMPOUND 4 (NO REACTION WITH NaOH ; PURELY OH)

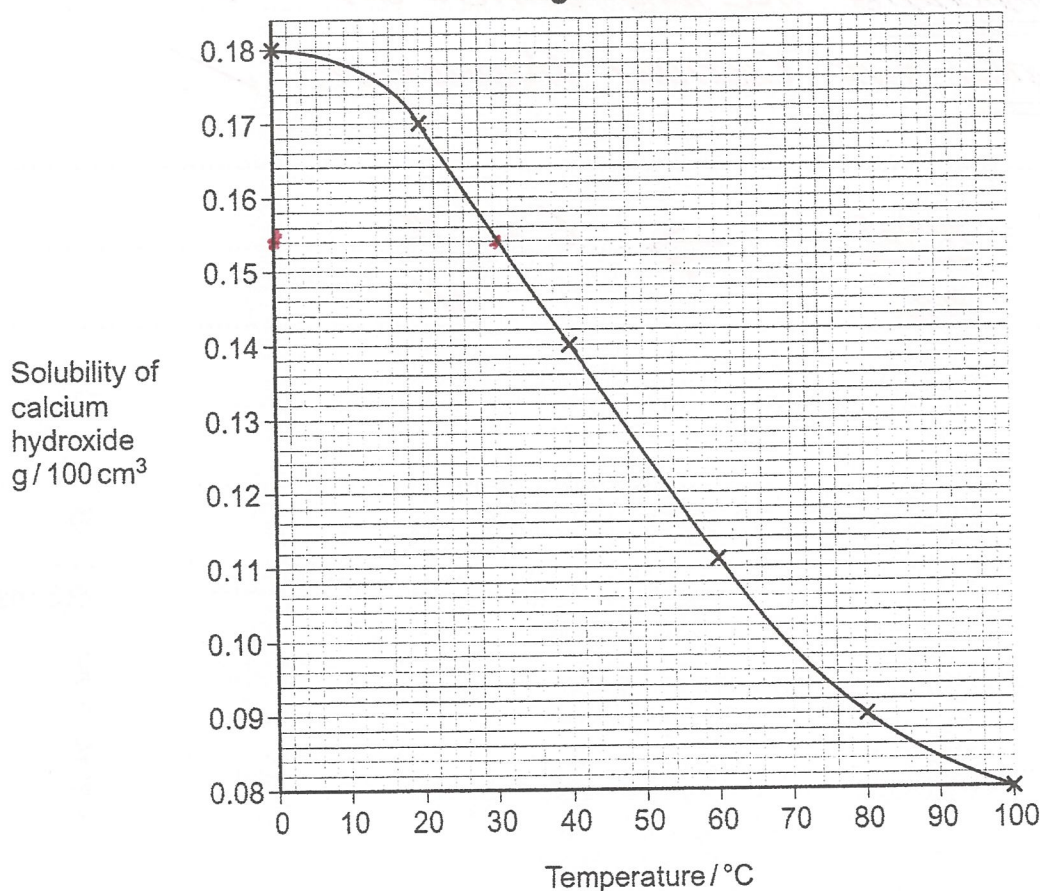
Equation $\text{Sr}(\text{OH})_2 + \text{H}_2\text{SO}_4 \rightarrow \text{SrSO}_4 + 2\text{H}_2\text{O}$

(2 marks)

3. Calcium hydroxide is slightly soluble in water at room temperature. As the temperature rises, the solubility decreases. When the maximum amount of solid has dissolved at a particular temperature the solution is said to be saturated.

In an experiment, the solubility of calcium hydroxide was measured over a range of temperatures. **Figure 1** shows the results.

Figure 1



- (a) Use data from **Figure 1b** to calculate the concentration, in mol dm⁻³, of a saturated solution of calcium hydroxide at 30 °C. Give your answer to 3 significant figures.

Show your working.

From graph solubility @ 30°C = 0.155 g per 100 cm³ ✓

$n \text{ Ca(OH)}_2 = \frac{0.155}{74.1} = 2.09 \times 10^{-3} \text{ moles per 100 cm}^3$

$C = \frac{n}{0.1} = 0.0209 \text{ mol dm}^{-3}$ ✓
3SF ✓

3SF
(3 marks)

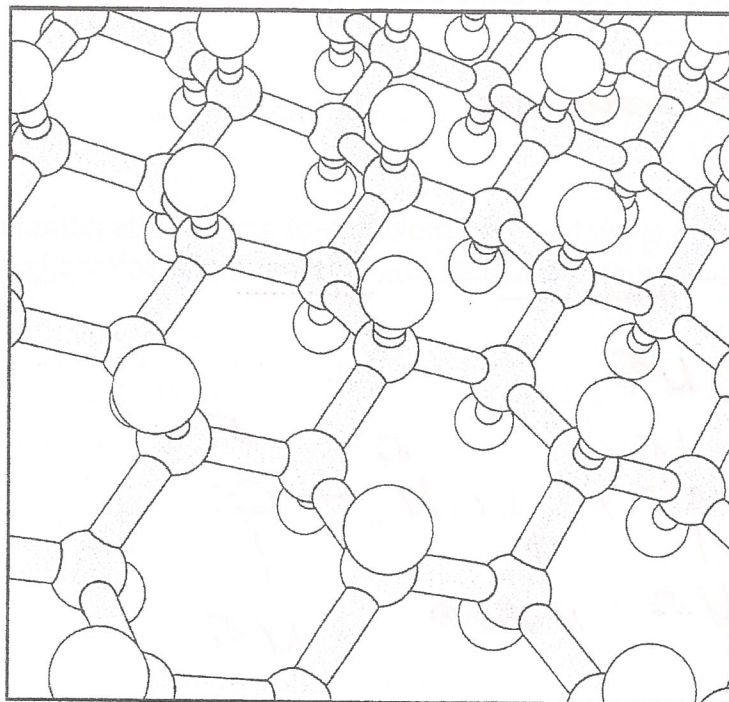
(b) You are given a sample of saturated calcium hydroxide solution. Outline the practical steps that you would take to determine the solubility of calcium hydroxide in this solution.

- MEASURE 100cm³ OF SATURATED SOLUTION ✓
- INTO AN EVAPORATING DISH
- EVAPORATE ALL THE WATER OFF ✓
- WEIGH THE CALCIUM HYDROXIDE ✓

$$\rho = \frac{\text{MASS}}{V} \Rightarrow C = \frac{\rho}{V}$$

(3 marks)

4. In 2009 a new material called graphane was discovered. The diagram shows part of a model of the structure of graphane. Each carbon atom is bonded to three other carbon atoms and to one hydrogen atom.



- (a) Deduce the type of crystal structure shown by graphane.

..... GIANT COVALENT

(1 mark)

- (b) State how two carbon atoms form a carbon-carbon bond in graphane.

..... ONE ELECTRON FROM EACH C ATOM PRODUCES
A SHARED PAIR OF ELECTRONS

(1 mark)

- (c) Suggest why graphane does not conduct electricity.

..... NO FREE MOVING ELECTRONS

S.A.

(1 mark)

- (d) Deduce the empirical formula of graphane.

..... CH (EACH C ATOM HAS 1 H ATOM)

(1 mark)

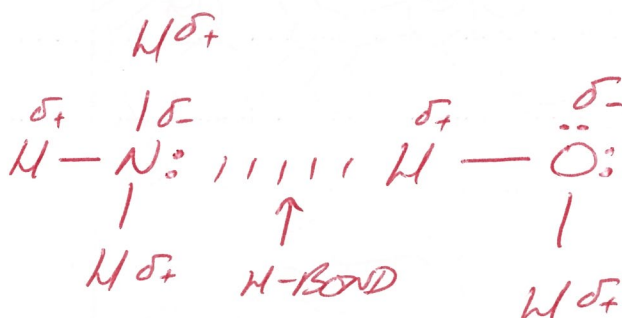
5. Fritz Haber, a German chemist, first manufactured ammonia in 1909.
Ammonia is very soluble in water.

- (a) State the strongest type of intermolecular force between one molecule of ammonia and one molecule of water.

H-BONDING

(1 mark)

- (b) Draw a diagram to show how one molecule of ammonia is attracted to one molecule of water. Include all partial charges and all lone pairs of electrons in your diagram.



PARTIAL CHARGES $\delta+$ / $\delta-$ ✓

ALL LONE PAIRS ✓

LABELLED BOND BETWEEN N: AND H ✓

(3 marks)

- (c) Phosphine (PH_3) has a structure similar to ammonia.

In terms of the intermolecular forces, suggest the main reason why phosphine is almost insoluble in water.

DOES NOT FORM H-BONDS

(1 mark)

6. Aluminium and thallium are elements in Group 3 of the Periodic Table.
Both elements form compounds and ions containing chlorine and bromine.

(a) Write an equation for the formation of aluminium chloride from its elements.



(b) An aluminium chloride molecule reacts with a chloride ion to form the AlCl_4^- ion.

Name the type of bond formed in this reaction. Explain how this type of bond is formed in the AlCl_4^- ion.

Type of bond DATIVE COVALENT

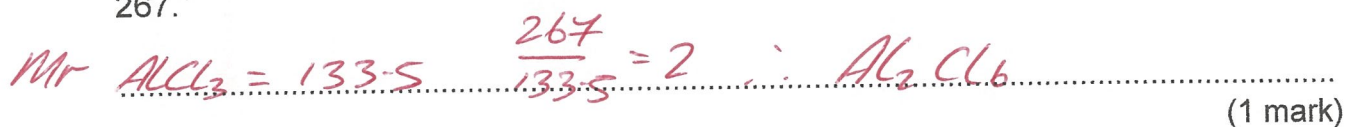
Explanation PAIR OF ELECTRONS ON Cl^- ARE DONATED TO AlCl_3 TO FORM A COVALENT BOND

S.A.

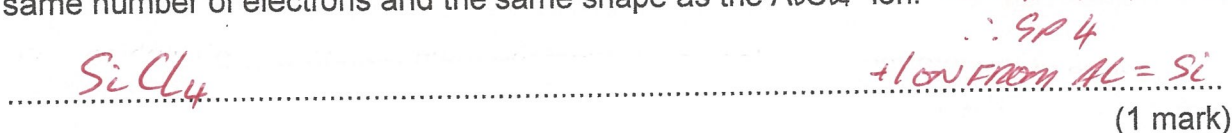
(2 marks)

(c) Aluminium chloride has a relative molecular mass of 267 in the gas phase.

Deduce the formula of the aluminium compound that has a relative molecular mass of 267.

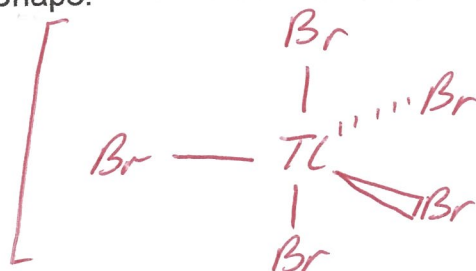


(d) Deduce the name or formula of a compound that has the same number of atoms, the same number of electrons and the same shape as the AlCl_4^- ion. TETRAHEDRAL SHAPE



(e) Draw and name the shape of the TlBr_5^- ion.

Shape:

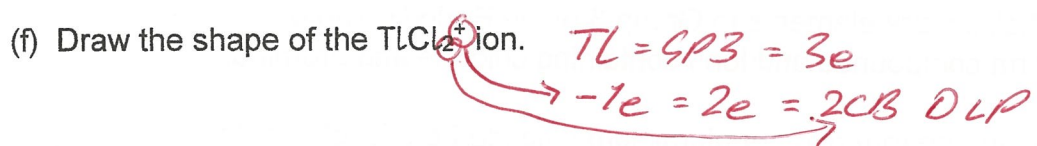


Name of shape

TRIGONAL BIPYRAMIDAL ✓

(2 marks)

(f) Draw the shape of the TlCl_2^+ ion.



(1 mark)

(g) Explain why the TlCl_2^+ ion has the shape you have drawn in part (f)

2 BONDING PAIRS OF e's / 0 LPAIRS OF e's

S.A. REPEL EQUALLY AS FAR AS POSSIBLE

(1 mark)

7. The elements in Period 2 show periodic trends.

- (a) Identify the Period 2 element, from carbon to fluorine, that has the largest atomic radius. Explain your answer.

Element... CARBON ✓

Explanation... ACROSS A PERIOD: ↑ GREATER ATTRACTION ✓

SAME (SHELLS)

S.A. SAME (SHIELDING) ✓

MORE (PROTONS)

(3 marks)

- (b) State the general trend in first ionisation energies from carbon to neon. Deduce the element that deviates from this trend and explain why this element deviates.

Trend... INCREASE IN 1ST IONISATION ENERGIES ✓

Element that deviates... OXYGEN ✓

Explanation... PAIRED ELECTRON IN P ORBITAL ✓

ELECTRONS REPEL ✓

(4 marks)

- (c) Write an equation, including state symbols, for the reaction that occurs when the first ionisation energy of carbon is measured.

C(g) → C⁺(g) + e⁻

(1 mark)

- (d) Explain why the second ionisation energy of carbon is higher than the first ionisation energy of carbon.

MORE ENERGY IS REQUIRED TO REMOVE AN ELECTRON FROM A (+)VE ION (ATTRACTION)

(1 mark)

8. Zinc forms many different salts including zinc sulfate, zinc chloride and zinc fluoride.

- (a) People who have a zinc deficiency can take hydrated zinc sulfate ($\text{ZnSO}_4 \cdot x\text{H}_2\text{O}$) as a dietary supplement.

A student heated 4.38 g of hydrated zinc sulfate and obtained 2.46 g of anhydrous zinc sulfate.

Use these data to calculate the value of the integer x in $\text{ZnSO}_4 \cdot x\text{H}_2\text{O}$

Show your working.

	ZnSO_4	H_2O	
MASS =	2.46	1.92 ✓	(4.38 - 2.46)
MOLBS =	2.46 / 161.5	1.92 / 18	✓
=	0.0152	:	0.107 (+SMALLEST)
$\frac{0.0152}{0.0152}$			
=	1	:	7 ✓
$\therefore x = 7 \quad \text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$			

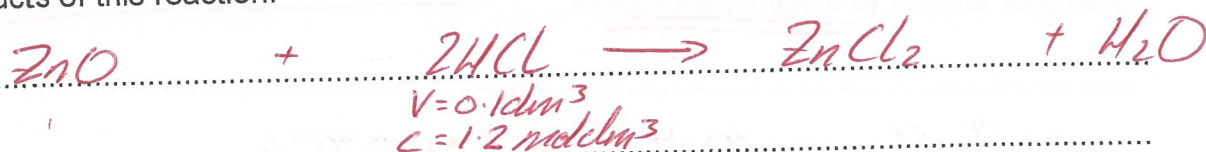
(3 marks)

- (b) Zinc chloride can be prepared in the laboratory by the reaction between zinc oxide and hydrochloric acid.
The equation for the reaction is



A 0.0830 mol sample of pure zinc oxide was added to 100 cm³ of 1.20 mol dm⁻³ hydrochloric acid.

Calculate the maximum mass of anhydrous zinc chloride that could be obtained from the products of this reaction.



MOLES. 0.0830 $\times 2$ $\rightarrow 0.166 \text{ MOLES (REQUIRED)}$

$0.12 \text{ MOLES (PRESENT)}$

$\therefore \text{ZnO}$ IS IN EXCESS

$\therefore$ USE $n \text{ HCl}$

$\text{HCl} : \text{ZnCl}_2$ IS 2:1 RATIO

$$\therefore n \text{ ZnCl}_2 = \frac{0.12}{2} = 0.06 \checkmark$$

(3 marks)

$$\text{MASS} = n \times M_r$$

$$= 0.06 \times 136.4$$

$$= \underline{\underline{8.18 \text{ g}}} \checkmark$$

- (c) Zinc chloride can also be prepared in the laboratory by the reaction between zinc and hydrogen chloride gas.



An impure sample of zinc powder with a mass of ^{5.68g} 5.68 g was reacted with hydrogen chloride gas until the reaction was complete. The zinc chloride produced had a mass of 10.7 g.

Calculate the percentage purity of the zinc metal.
Give your answer to 3 significant figures.

$$n \text{ ZnCl}_2 = \frac{10.7}{136.4} = 0.0784$$

$$n \text{ Zn} = 0.0784 \text{ (1:1 ratio)} \quad \checkmark$$

$$\text{mass Zn} = n \times \text{Ar}$$

$$= 0.0784 \times 65.4 = 5.13\text{g} \quad \checkmark$$

$$\% \text{ purity} = \frac{5.13}{5.68} \times 100 = 90.3\% \quad \checkmark$$

(3 marks)

- (d) Predict the type of crystal structure in solid zinc fluoride and explain why its melting point is high.

IONIC $\checkmark$

STRONG ELECTROSTATIC FORCES OF ATTRACTION $\checkmark$

BETWEEN OPPOSITELY CHARGED IONS $\checkmark$

(3 marks)

9. Chlorine displaces iodine from aqueous potassium iodide.

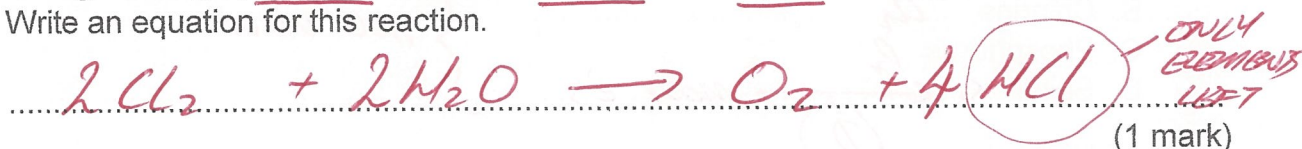
(a) Write the **simplest ionic** equation for this reaction.



(b) Give **one** observation that you would make when this reaction occurs.

SOLUTION TURNS BROWN (1 mark)

(c) In bright sunlight, chlorine reacts with water to form oxygen as one of the products. Write an equation for this reaction.



(d) Explain why chlorine has a lower boiling point than bromine.

S.A. Cl_2 HAS FEWER ELECTRONS ✓
∴ VDW FORCES OF ATTRACTION ARE WEAKER ∴ LESS ENERGY REQUIRED ✓

(2 marks)

10. Which one of the ionisations of thallium produces an ion with the electron configuration $[\text{Xe}]5d^{10}6s^1$

- A. first
- B. second
- C. third
- D. fourth

Answer..... B

(1 mark)

11. Which of the following elements has the highest melting point.

- A. Argon *Ar*
 - B. Chlorine *Cl₂*
 - C. Phosphorus *P₄*
 - D. Sulfur *S₈* ← *most e's*
- } ALL VDW*

Answer..... D

(1 mark)

12. Which is a list of elements in order of increasing first ionisation energy?

- A. ²F, ¹Ne, ³Na
- B. ³Sr, ²Ca, ¹Mg ✓
- C. ¹Cl, ²P, ³Si
- D. ¹Cl, ²Br, ³I

Answer..... B

(1 mark)

13. Which description of electron configuration applies to atoms of potassium, chromium and copper?

- A. only one half-filled orbital *x Cr ONLY*
- B. only one filled sublevel *x*
- C. only nine filled orbitals ✓
- D. only five filled sublevels. *x*

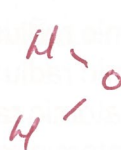
Answer..... C

(1 mark)

14. The most abundant isotopes of hydrogen and oxygen are ^1H , ^2H , ^{16}O and ^{17}O , respectively. Using these isotopes only, what is the number of different possible values for the molar mass of water?

- A. 3
- B. 4
- C. 5
- D. 6

Answer..... **(B)**



	16	17
1/1 = 2	18	19
1/2 = 3	19	20
2/2 = 4	20	21

4 POSSIBILITIES

(1 mark)

15. Which pair of atoms represents nuclei that have the same number of neutrons.

- A. ^{56}Co and ^{58}Co ~~x~~
- B. ^{58}Ni and ^{57}Co
- C. ^{58}Ni and ^{57}Fe
- D. ^{59}Ni and ^{56}Fe

30 : 30 ✓

Answer..... **(B)**

(1 mark)

16. Which of the following metal oxides has the greatest percentage by mass of oxygen?

- A. barium oxide
- B. beryllium oxide
- C. calcium oxide
- D. magnesium oxide

~~BAD~~ ALL GP2 : SMALLEST GP2 METAL GIVES HIGHEST % OF OXYGEN

Answer..... **(B)**

(1 mark)

17. Which pair of samples contains the same number of oxygen atoms in each compound?

- A. 0.10 mol Al_2O_3 and 0.50 mol BaO 0.3 : 0.5
- B. 0.20 mol SnO and 0.20 mol SnO_2 0.2 : 0.4
- C. 0.10 mol Na_2O and 0.10 mol Na_2SO_4 0.1 : 0.4
- D. 0.20 mol $\text{Ca}(\text{OH})_2$ and 0.10 mol $\text{H}_2\text{C}_2\text{O}_4$ 0.4 : 0.4

Answer..... **(D)**

(1 mark)

18. Which pair of compounds produces a white precipitate when mixed?

- A. MgO and H_2SO_4
- B. AgNO_3 and KBr
- C. Na_2CO_3 and HNO_3
- D. NaCl and AgNO_3

Answer..... **(D)**

(1 mark)

19. Which of the following statements is true across Period 3 of the Periodic Table?

- A. As atomic number increases atomic radius decreases ✓
- B. As atomic number increases atomic radius increases ✗
- C. As atomic number increases the atomic radius remains the same ✗
- D. As atomic number increases the atomic radius increases to a maximum and then decreases. ✗

Answer..... (A)

(1 mark)

20. Which has the smallest bond angle?

- A. CH₄ 109.5
- B. CO₂ 180
- C. NH₃ 107
- D. SF₆ 90

Answer..... (D)

(1 mark)

21. Which is the most likely formula for hydrogen arsenide?

- A. HAs
- B. HAs₂
- C. H₂As
- D. H₃As

As is 5th row like N
∴ NH₃ of H₃As

Answer..... (D)

(1 mark)

22. A 20 cm³ sample of solution is to be added to a reaction mixture. Which piece of equipment would provide the most precise measurement of the solution?

- A. A 25 cm³ volumetric flask ✗
- B. A 25 cm³ bulb pipette ✗
- C. A 25 cm³ measuring cylinder
- D. A 50 cm³ burette.

} GRADUATED BUT BURETTE HAS SMALLER DIVISIONS.

Answer..... (D)

(1 mark)

23. Why is chlorine used to treat local water supplies?

- A. to make water suitable for swimming
- B. to kill micro-organisms living in the water
- C. to promote sedimentation of finely suspended solids
- D. to precipitate heavy metal ions such as lead and mercury.

Answer..... B

(1 mark)

24. In a titration of a sodium hydroxide with hydrochloric acid the following procedure was used:

- A burette was rinsed with water and then filled with hydrochloric acid of known concentration. *∴ HCL MORE DILUTE ∴ MORE ADDED ∴ MORE*
- A pipette was rinsed with some sodium hydroxide solution ✓ *MORE HCL*
- A conical flask was rinsed with some sodium hydroxide solution. ✓ *∴ MORE MOLES NaOH = BIGGER*
- the pipette was used to transfer a measured volume of the sodium hydroxide solution to the conical flask. ✓ *CONC. OF NaOH*
- Indicator was added to the conical flask and the sodium hydroxide was titrated to the endpoint with the acid. ✓

Which statement is correct?

- A. the calculated base concentration will be correct
- B. the calculated base concentration will be too low
- C. the calculated base concentration will be too high
- D. No definite conclusion can be reached about the base concentration.

Answer..... C

(1 mark)

Question	Marks available	Marks awarded	Comments
1	7		
2	8		
3	6		
4	4		
5	5		
6	9		
7	9		
8	12		
9	5		
10	1		
11	1		
12	1		
13	1		
14	1		
15	1		
16	1		
17	1		
18	1		
19	1		
20	1		
21	1		
22	1		
23	1		
24	1		
Total	80		