

**SECTION A****(1 mark for each correct response = 20 marks)**

1.	<b>C</b>	2.	<b>B</b>	3.	<b>B</b>	4.	<b>C</b>	5.	<b>D</b>
6.	<b>B</b>	7.	<b>D</b>	8.	<b>C</b>	9.	<b>C</b>	10.	<b>B</b>
11.	<b>D</b>	12.	<b>C</b>	13.	<b>A</b>	14.	<b>C</b>	15.	<b>D</b>
16.	<b>B</b>	17.	<b>A</b>	18.	<b>C</b>	19.	<b>A</b>	20.	<b>D</b>

**Discussion of Multiple Choice Answers**

- Silver chloride is insoluble in water but ethanol is soluble. **Ans: C**
- When the water is boiled, it evaporates and leaves the salt behind. **Ans: B**
- Chlorine is well known for its germicidal properties. **Ans: B**
- Ionic compounds dissociate whilst molecular compounds ionize. **Ans: C**
- A, B and C are essentially non-polar and are insoluble in water. Ammonia is able to form hydrogen bonds but ammonia is much more soluble (ammonia fountain demonstration). **Ans: D**
- Silver chloride is insoluble (see solubility table). All others are soluble. **Ans: B**
- $C = n/V$  so  $V = n/C = 0.03 / 0.4 = 0.075 \text{ L} = 75 \text{ mL}$ . **Ans: D**
- Anions are negative ions, in this case  $\text{Cl}^-$  ions.  $n(\text{MgCl}_2) = 0.0200 \Rightarrow n(\text{Cl}^-) \text{ ions} = 0.0400$   $N(\text{Cl}^-) = 0.0400 \times 6.0 \times 10^{23} = 0.240 \times 10^{23}$  **Ans: C**
- $n(\text{Mg}) = m/M = 0.243/24.3 = 0.0100 \text{ mol} \Rightarrow n(\text{HCl}) = 2 n(\text{Mg}) = 0.0200 \text{ mol}$  **Ans: C**
- $n(\text{H}_2) = n(\text{Mg}) = 0.0100 \text{ mol}$   
 $V(\text{H}_2) = n \times V_m = 0.0100 \times 24.5 \text{ L} = 0.245 \text{ L} = 245 \text{ mL}$  **Ans: B**
- 3 mol of  $\text{CO}_2$  can only react with 1.5 mol of  $\text{O}_2$   
Hence  $\text{O}_2$  is in excess by 0.5 mol **Ans: D**
- The concentration of protons per unit volume indicates the strength of an acidic solution. **Ans: C**
- A salt + water as the only products is a generalisation for acid / base reactions. For carbonates and hydrogencarbonates,  $\text{CO}_2$  is also produced. **Ans: A**
- $[\text{OH}^-] = 0.050$   $\text{pOH} = -\log_{10} 0.050 = 1.3$ ;  $\text{pH} + \text{pOH} = 14 \Rightarrow \text{pH} = 12.7$  **Ans: C**

15. Galvanic cells produce electricity via a spontaneous redox reaction. **Oxidation** occurs at the **anode** which is the **negative** electrode as it is supplying electrons to the external circuit. As a consequence, **anions** migrate into the **anode half cell** to balance the charge. **Ans: D**
16. Halogenated hydrocarbons eg CFC's are known to produce haloradicals eg  $\text{Cl}\cdot$  which destroy ozone and are recycled to keep on repeating this process. **Ans: B**
17. Gases are most compressed at both **low** temperatures and **high** pressures. **Ans: A**
18.  $pV = nRT$  ; at constant volume and temperature  $p \propto n$  (Avogadro's Law).  
Therefore  
both gases must have the same number of molecules. **Ans: C**
19.  $V_m$  (volume of 1 mol) =  $RT / p = 8.31 \times 373 / 101.3 = 30.6$  **Ans: A**
20.  $4 \text{Li(s)} + \text{O}_2(\text{g}) \rightarrow 2 \text{Li}_2\text{O}$
- $n(\text{Li}_2\text{O}) = m / M = 15/30 = 0.5 \text{ mol}$ ;  $n(\text{Li}) = 2 n(\text{Li}_2\text{O}) = 1.0 \text{ mol}$
- $m(\text{Li}) = n \times M = 1.0 \times 6.94 = 6.94 \text{ g} = 7.0 \text{ g}$  **Ans: D**

## SECTION B

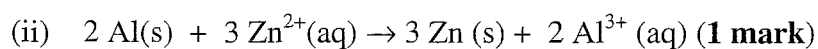
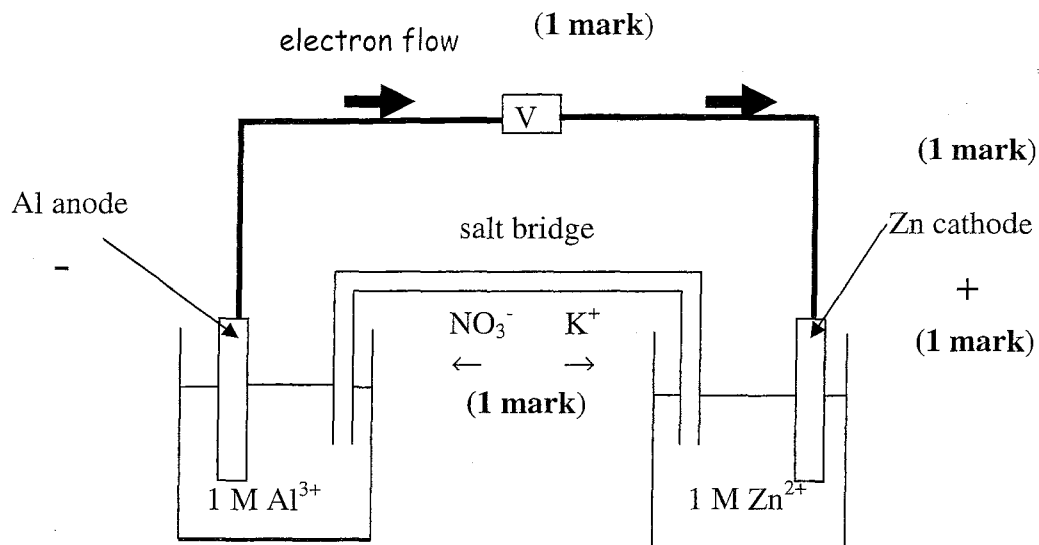
### Question 1 (3 + 3 + 1 + 1 = 8 marks)

- (a)  $\text{Ca(OH)}_2$ ,  $\text{Al}_2(\text{SO}_4)_3$ ,  $\text{Al(OH)}_3$  (3 x 1 = 3 marks)
- (b) (i) Calcium hydroxide (1 mark)
- (ii)  $\text{Ca(OH)}_2(\text{s}) \rightarrow \text{Ca}^{2+}(\text{aq}) + 2\text{OH}^-(\text{aq})$  (1 mark)  
 $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O(l)}$  (1 mark)
- (c)  $\text{Al}^{3+}(\text{aq}) + 3\text{OH}^-(\text{aq}) \rightarrow \text{Al(OH)}_3(\text{s})$  (1 mark)
- (d) Sulfate ions are **spectator** ions ie. they do not take part in the reaction (1 mark)

### Question 2 (1 + 3 + 6 = 10 marks)

- (a) A reducing agent causes the reduction of an oxidant but at the same time is oxidized. Zn is the reducing agent since it is oxidised from Zn to  $\text{Zn}^{2+}$  (1 mark)
- (b) (i) Any two of the following, 1 mark each: Magnesium dissolves, blue colour of copper ions diminishes, deposit of red brown solid, temperature increases. (2 marks)
- (ii)  $\text{Mg(s)} + \text{Cu}^{2+}(\text{aq}) \rightarrow \text{Cu(s)} + \text{Mg}^{2+}(\text{aq})$  (1 mark)

- (c) (i) Overall diagram of galvanic cell including the salt bridge (1 mark)



**Question 3 (2 + 2 + 3 + 2 = 9 marks)**

- (a) The reaction is a redox reaction. C is oxidised to CO (oxidation number increases from 0 to +2) (1 mark) and  $\text{SiO}_2$  is reduced to silicon (oxidation number of silicon decreases from +4 to 0) (1 mark)

(b)  $n(\text{C}) = m / M = 108 / 12 = 9.0 \text{ mol}$  (1 mark)

$n(\text{SiO}_2) = m / M = 360 / 60 = 6.0 \text{ mol}$  (1 mark)

(c)

	C	$\text{SiO}_2$	Si	$\text{CO}_2$
Mole ratio	2	1	1	2
$n_{\text{initial}}$	9.0 mol	6.0 mol		
$n_{\text{reacting}}$	9.0 mol	4.5 mol		
$n_{\text{produced}}$			4.5 mol	9.0 mol
$n_{\text{in excess}}$		1.5 mol		

Working to indicate that  $\text{SiO}_2$  is in excess (1 mark)

$n(\text{SiO}_2) \text{ in excess} = 1.5 \text{ mol}$  (1 mark)

$m(\text{SiO}_2) = n \times M = 1.5 \times 60 = 90 \text{ g}$  (1 mark)

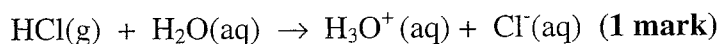
- (d)  $n(\text{Si}) = n(\text{SiO}_2)$  reacting (1 mark)  
 $m(\text{Si}) = n \times M = 4.5 \times 28.1 = 1.3 \times 10^2 \text{ g}$  (2 sf) (1 mark)

**Question 4 (3 + 2 + 1 = 6 marks)**

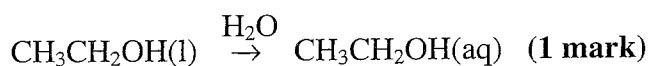
- (a) (i)  $\text{CO}_2$  dissolves slightly with water and reacts with it to form the weak carbonic acid,  $\text{H}_2\text{CO}_3$ . (1 mark)  
 (ii)  $\text{H}_2\text{CO}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_3\text{O}^+(\text{aq}) + \text{HCO}_3^-(\text{aq})$  (1 mark)  
 The increase in  $[\text{H}_3\text{O}^+]$  decreases the pH (1 mark)
- (b) (i)  $\text{CaCO}_3(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{Ca}^{2+}(\text{aq}) + \text{CO}_2(\text{g})$  (1 mark)  
 (ii)  $\text{CaO}(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l}) + \text{Ca}^{2+}(\text{aq})$  (1 mark)
- (c)  $2\text{NO}(\text{g}) + 2\text{CO}(\text{g}) \rightarrow \text{N}_2(\text{g}) + 2\text{CO}_2(\text{g})$  (1 mark)

**Question 5 (4 marks)**

HCl ionises in water to create ions (1 mark)



Ethanol molecules,  $\text{CH}_3\text{CH}_2\text{OH}$ , remain intact but separate from each other because of their ability to form hydrogen bonds with water molecules. (1 mark)



**Question 6 (2 + 1 = 3 marks)**

- (a) mass of atoms in the final commercial product  
 $= M_r \text{CH}_3\text{CH}_2\text{Br} = 2 \times 12 + 5 \times 1 + 79.9 = 108.9 \text{ g mol}^{-1}$  (1 mark)  
 Total mass of reactants =  
 $M(\text{CH}_3\text{CH}_2\text{OH}) + M(\text{NaBr}) + M(\text{H}_2\text{SO}_4) = 46.0 + 102.9 + 98.1 = 247.0 \text{ g}$   
 Therefore % atom economy =  $(108.9 / 247.0) \times 100 = 44.09\%$  (1 mark)
- (b)  $\text{H}_2\text{SO}_4$  is acting as an acid as it transfers a proton to the  $-\text{OH}$  group to form water. (1 mark)

**Question 7 (2 + 3 + 3 + 1 + 3 = 12 marks)**

- (a) For a dilution,
- $n_1 = n_2$
- or
- $c_1V_1 = c_2V_2$
- (1 mark)

$$14 \times V_1 = 0.1 \times 2$$

$$V_1 = 0.2 / 14 = 0.0143 \text{ L} = 14.3 \text{ mL} \text{ (1 mark)}$$

Therefore 14.3 mL of 14 M nitric acid are required.

- (b)
- $n(\text{Na}_2\text{CO}_3) = c V = 0.05 \times 0.25 = 0.0125 \text{ mol}$
- (1 mark)

$$M(\text{Na}_2\text{CO}_3) = 2 \times 23.0 + 12.0 + (3 \times 16.0) = 106 \text{ g mol}^{-1} \text{ (1 mark)}$$

$$m(\text{Na}_2\text{CO}_3) = n \times M = 0.0125 \times 106 = 1.325 \text{ g} \text{ (1 mark)}$$

- (c) (i) Complete the table (1 mark)

Titration	1	2	3	4	5
Titre (mL)	20.30	19.70	19.90	19.80	17.65

- (ii) Concordant titres are results that vary within
- $\pm 0.1$
- mL

The concordant titres are from titrations 2, 3 and 4 (1 mark)

2	3	4
19.70	19.90	19.80

$$\text{Ave titration} = (19.70 + 19.90 + 19.80) \div 3 = 19.8 \pm 0.1 \text{ mL} \text{ (1 mark)}$$

- (d) An aliquot would be taken with a
- pipette**
- (1 mark)

- (e)
- $n(\text{Na}_2\text{CO}_3) = c V = 0.05005 \times 19.8 \times 10^{-2} = 9.91 \times 10^{-4} \text{ mol}$
- (1 mark)

$$n(\text{HNO}_3) = 2 \times n(\text{Na}_2\text{CO}_3) \text{ (1 mark)}$$

$$[\text{HNO}_3] = n / V = 2 \times 9.91 \times 10^{-4} / 0.02000 = 0.0991 \text{ mol L}^{-1} \text{ (1 mark)}$$

**END OF SUGGESTED SOLUTIONS**