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

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

Discussion of Multiple Choice Answers

1. Silver chloride is insoluble in water but ethanol is soluble. **Ans: C**

2. When the water is boiled, it evaporates and leaves the salt behind. **Ans: B**

3. Chlorine is well known for its germicidal properties. **Ans: B**

4. Ionic compounds dissociate whilst molecular compounds ionize. **Ans: C**

5. 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**

6. Silver chloride is insoluble (see solubility table). All others are soluble. **Ans: B**

7. $C = n/V$ so $V = n/C = 0.03 / 0.4 = 0.075$ L = 75 mL. **Ans: D**

8. Anions are negative ions, in this case Cl^- ions. $n(MgCl_2) = 0.0200 \Rightarrow$ $n(Cl^-)$ ions $= 0.0400$ $N(Cl^-) = 0.0400 \times 6.0 \times 10^{23} = 0.240 \times 10^{23}$ **Ans: C**

9. $n(Mg) = m/M = 0.243/24.3 = 0.0100$ mol $\Rightarrow$ $n(HCl) = 2\ n(Mg) = 0.0200$ mol **Ans: C**

10. $n(H_2) = n(Mg) = 0.0100$ mol

$V(H_2) = n \times Vm = 0.0100 \times 24.5$ L = 0. 245 L = 245 mL **Ans: B**

11. 3 mol of CO_2 can only react with 1.5 mol of O_2
Hence O_2 is in excess by 0.5 mol **Ans: D**

12. The concentration of protons per unit volume indicates the strength of an acidic solution. **Ans: C**

13. A salt + water as the only products is a generalisation for acid / base reactions. For carbonates and hydrogencarbonates, CO_2 is also produced. **Ans: A**

14. $[OH^-] = 0.050$ $pOH = -\log_{10} 0.050 = 1.3$; $pH + pOH = 14 \Rightarrow pH = 12.7$ **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 Cl• 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 $p \propto n$ (Avogadros'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 x 373 / 101.3 = 30.6 **Ans: A**

20. $4\ Li(s) + O_2(g) \rightarrow 2\ Li_2O$

$n(Li_2O) = m / M = 15/30 = 0.5$ mol; $n(Li) = 2\ n(Li_2O) = 1.0$ mol

$m(Li) = n \times M = 1.0 \times 6.94 = 6.94\ g = 7.0\ g$ **Ans: D**

SECTION B

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

(a) $Ca(OH)_2$, $Al_2(SO_4)_3$, $Al(OH)_3$ **(3 x 1 = 3 marks)**

(b) (i) Calcium hydroxide **(1 mark)**

(ii) $Ca(OH)_2(s) \rightarrow Ca^{2+}(aq) + 2OH^-(aq)$ **(1 mark)**
$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$ **(1 mark)**

(c) $Al^{3+}(aq) + 3OH^-(aq) \rightarrow Al(OH)_3(s)$ **(1 mark)**

(d) Sulfate ions are **spectator** ions ie. they do not take part in the reaction **(1 mark)**

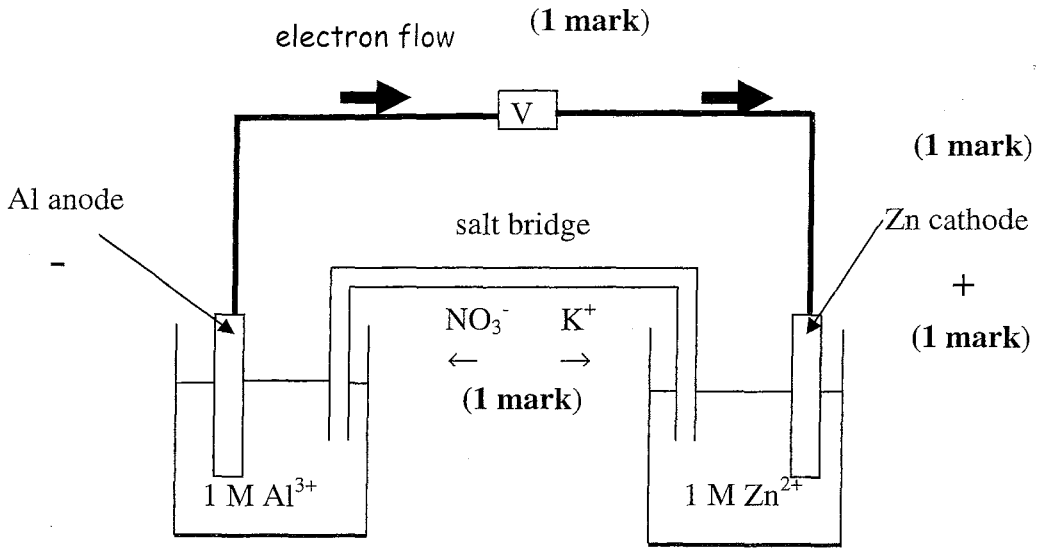
Question 2 (1 + 3 + 6 = 10 marks)

(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 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) $Mg(s) + Cu^{2+}(aq) \rightarrow Cu(s) + Mg^{2+}(aq)$ **(1 mark)**

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



(ii) $2\ Al(s) + 3\ Zn^{2+}(aq) \rightarrow 3\ Zn\ (s) + 2\ Al^{3+}\ (aq)$ **(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 SiO_2 is reduced to silicon (oxidation number of silicon decreases from +4 to 0) **(1 mark)**

(b) n(C) = m / M = 108 / 12 = 9.0 mol **(1 mark)**

$n(SiO_2)$ = m / M = 360 / 60 = 6.0 mol **(1 mark)**

(c)

	C	SiO_2	Si	CO_2
Mole ratio	2	1	1	2
$n_{initial}$	9.0 mol	6.0 mol		
$n_{reacting}$	9.0 mol	4.5 mol		
$n_{produced}$			4.5 mol	9.0 mol
$n_{in\ excess}$		1.5 mol		

Working to indicate that SiO_2 is in excess **(1 mark)**
$n(SiO_2)$ in excess = 1.5 mol **(1 mark)**
$m(SiO_2)$ = n x M = 1.5 x 60 = 90 g **(1 mark)**

(d) $n(Si) = n(SiO_2)$ reacting **(1 mark)**
$m(Si) = n \times M = 4.5 \times 28.1 = 1.3 \times 10^2$ g (2 sf) **(1 mark)**

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

(a) (i) CO_2 dissolves slightly with water and reacts with it to form the weak carbonic acid, H_2CO_3. **(1 mark)**

(ii) $H_2CO_3\,(aq) + H_2O(l) \rightarrow H_3O^+\,(aq) + HCO_3^-\,(aq)$ **(1 mark)**
The increase in $[H_3O^+]$ decreases the pH **(1 mark)**

(b) (i) $CaCO_3(s) + 2H^+(aq) \rightarrow H_2O(l) + Ca^{2+}(aq) + CO_2(g)$ **(1 mark)**

(ii) $CaO(s) + 2H^+(aq) \rightarrow H_2O(l) + Ca^{2+}(aq)$ **(1 mark)**

(c) $2NO\,(g) + 2CO\,(g) \rightarrow N_2\,(g) + 2CO_2\,(g)$ **(1 mark)**

Question 5 (4 marks)

HCl ionises in water to create ions **(1 mark)**

$HCl(g) + H_2O(aq) \rightarrow H_3O^+\,(aq) + Cl^-(aq)$ **(1 mark)**

Ethanol molecules, CH_3CH_2OH, remain intact but separate from each other because of their ability to form hydrogen bonds with water molecules. **(1 mark)**

$CH_3CH_2OH(l) \overset{H_2O}{\rightarrow} CH_3CH_2OH(aq)$ **(1 mark)**

Question 6 (2 + 1 = 3 marks)

(a) mass of atoms in the final commercial product
$= M_r\ CH_3CH_2Br = 2 \times 12 + 5 \times 1 + 79.9 = 108.9$ g mol^{-1} **(1 mark)**
Total mass of reactants =
$M\,(CH_3CH_2OH) + M\,(NaBr) + M\,(H_2SO_4) = 46.0 + 102.9 + 98.1 = 247.0$ g

Therefore ***% atom economy*** $= (108.9 / 247.0) \times 100 = 44.09$ % **(1 mark)**

(b) H_2SO_4 is ***acting as an acid as it transfers a proton*** to the –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)**

$14 \times V_1 = 0.1 \times 2$

$V_1 = 0.2 / 14 = 0.0143$ L = 14.3 mL **(1 mark)**

Therefore 14.3 mL of 14 M nitiric acid are required.

(b) $n(Na_2CO_3) = c\ V = 0.05 \times 0.25 = 0.0125$ mol **(1 mark)**

$M(Na_2CO_3) = 2 \times 23.0 + 12.0 + (3 \times 16.0) = 106$ g mol^{-1} **(1 mark)**

$m(Na_2CO_3) = n \times M = 0.0125 \times 106 = 1.325$ g **(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 ± 0.1 mL

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

2	**3**	**4**
19.70	19.90	19.80

Ave titration = (19.70 + 19.90 + 19.80) ÷ 3 = 19.8 ± 0.1 mL **(1 mark)**

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

(e) $n(Na_2CO_3) = c\ V = 0.05005 \times 19.8 \times 10^{-2} = 9.91 \times 10^{-4}$ mol **(1 mark)**

$n(HNO_3) = 2 \times n(Na_2CO_3)$ **(1 mark)**

$[HNO_3] = n / V = 2 \times 9.91 \times 10^{-4} / 0.02000 = 0.0991$ mol L^{-1} **(1 mark)**

END OF SUGGESTED SOLUTIONS