



**Year 12
Chemistry
2008**

SOLUTIONS

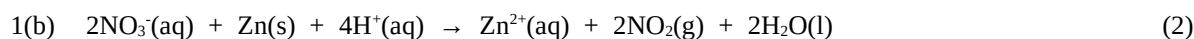
Part 1:

1	(a)	11	(d)	21	(a)
2	(b)	12	(b)	22	(a)
3	(d)	13	(b)	23	(b)
4	(a)	14	(b)	24	(a)
5	(c)	15	(b)	25	(a)
6	(d)	16	(c)	26	(a)
7	(a)	17	(b)	27	(c)
8	(c)	18	(b)	28	(c)
9	(a)	19	(d)	29	(d)
10	(a)	20	(c)	30	(c)

(60)

Part 2:

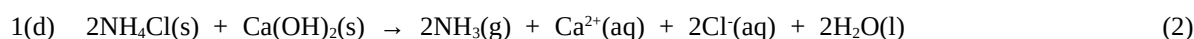
Red substance forms in colourless solution; pale green gas dissolves (disappears). (1)



Brown pungent gas is evolved; silvery metal dissolves. (1)



White solid dissolves to form a colourless solution. (1)



Two white powdered solids when heated produce a colourless liquid and a pungent colourless gas. (1)



3 (i) HCl is a polar molecule which forms dipole-dipole bonding to adjacent like molecules in the liquid phase. Cl_2 is a non-polar molecule which forms only weak dispersion forces between adjacent molecules. Since the HCl molecules are held together by stronger forces than the Cl_2 molecules, more energy is needed to separate the former, so HCl has a higher boiling point. (3)

(ii) PF_3 molecules are pyramidal with the $\text{P} \rightarrow \text{F}$ bond dipoles facing down towards the base of the pyramid. These dipoles add to produce an overall molecular dipole, so PF_3 is polar.

BF_3 molecules are nonpolar because the BF_3 molecules are planar triangular, with symmetrical $\text{B} \rightarrow \text{F}$ bond dipoles cancelling out, so BF_3 is non-polar. (4)

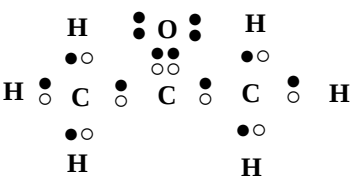
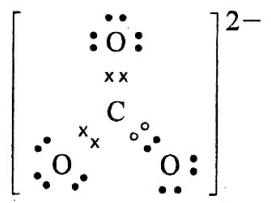
(iii) Mg metal is more active than Fe, and forms the anode of an electrochemical cell with the iron hull of the ship and the seawater electrolyte. Since the Mg has a higher tendency to oxidise (lose electrons) than the iron, the latter cannot lose electrons in this environment, and is thus

protected from rusting.

- (3)
 4. (a) $\text{Cu(s)} \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{e}^-$ (1)
 (b) Arrow in the box must point to the right (\rightarrow) (1)
 (c) $\text{Cu}^{2+}(\text{aq})$ or $\text{NH}_4^+(\text{aq})$ (1)
 (d) 0.46 volts. (2)

5. Ionisation energy is the energy required to remove a mole of electrons from a mole of atoms or ions of an element in the gaseous phase. (2)
 Electronegativity is the electron attracting ability of an atom in a covalent bond. (2)

6.

 <p>(a) propanone</p>	 <p>(b) carbonate ion</p>
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 (6)

7. (a) The colour of the gas mixture darkens at first, but then becomes lighter brown. (1)
 Initially, compressing the gases causes a darkening of the colour due to the increase in density, but then the system reacts to the change. LCP predicts that if the pressure on an equilibrium gas mixture is increased, the system will try to reduce the pressure. It can do this by favouring the reaction which produces fewer gas molecules. Hence, more colourless $\text{N}_2\text{O}_4(\text{g})$ is formed, so the colour will fade. (2)
- (b) The colour of the gas mixture darkens. (1)
 The forward reaction producing $\text{N}_2\text{O}_4(\text{g})$ is exothermic. LCP predicts that if temperature is increased, the system will favour the reaction which consumes heat. Hence, the reverse reaction is favoured, so more brown $\text{NO}_2(\text{g})$ is formed, causing the gas mixture to darken. (2)
8. The titration between a weak base and strong acid has an equivalence point which is acidic ie $\text{pH} < 7$. To avoid titration errors, the end point of the indicator should match the equivalence point - the point in the titration when chemically equivalent amounts of acid and base have been combined. Methyl Orange has an end point (colour change) around $\text{pH} = 4$, which is a close match to the equivalence point. If PhTh is used, its end point is basic ($\text{pH} = 8$), so the colour change would occur before sufficient acid has been added, resulting in a titration error. The calculated concentration of the acid would be greater than its true value. (4)

9.

$\text{CH}_3\text{CH}_2\text{CH}_2\text{CHOHCH}_3$ 2-pentanol	$\text{CH}_3\text{CH}_2\text{C}(\text{CH}_3)\text{OHCH}_3$ 2-methyl-2-butanol
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 (4)

10. "Amphoteric" refers to the chemical property of a substance whereby it can act as an acid or a base in certain reactions. (1)
 $\text{Zn(s)} + 2\text{OH}^-(\text{aq}) + 2\text{H}_2\text{O(l)} \rightarrow [\text{Zn}(\text{OH})_4]^{2-}(\text{aq}) + \text{H}_2(\text{g})$ (1)
 $\text{Zn(s)} + 2\text{H}^+(\text{aq}) \rightarrow \text{Zn}^{2+}(\text{aq}) + \text{H}_2(\text{g})$ (1)
 The first reaction shows zinc metal reacting as an acid. The second shows zinc acting as a base. (1)
11. 1. Add hydrochloric acid. (1)
 One white solid will produce bubbles of colourless gas. (1)
 The substance which produces gas bubbles with the acid is the aluminium carbonate. (1)
 2. Add $\text{BaCl}_2(\text{aq})$. (1)
 One solution will produce a white precipitate. (1)
 The substance which produced the white precipitate is the sodium sulfate. (1)
 3. Add $\text{Na}_2\text{SO}_4(\text{aq})$. (1)

One solution will produce a white precipitate. (1)

The one which produces the white precipitate is the barium hydroxide. (1)

Note: There are a number of alternative answers to this question based on various solubility rules.

Part 3:

1 $n(\text{HCl}) = c.V = (0.502 \text{ mol L}^{-1})(0.150 \text{ L}) = 0.0753 \text{ mol}$. (1)

$n(\text{HOCl}) = m/M = (2.00 \text{ g}) / (52.458 \text{ g mol}^{-1}) = 0.03813 \text{ mol}$ (1)

From balanced equation, $n(\text{HOCl}) = n(\text{HCl})$ (1)

Hence, the limiting reagent is the HOCl(aq)

(1)

The reaction consumes all the HOCl.

Hence the reaction is: $0.03813 \text{ mol HOCl} + 0.03813 \text{ mol HCl} \rightarrow 0.03813 \text{ mol Cl}_2(\text{g})$

$n(\text{Cl}_2) = 0.03813 \text{ mol}$. (2)

$V(\text{Cl}_2)_{(\text{STP})} = (0.03813 \text{ mol})(22.41 \text{ L mol}^{-1}) = 0.8544 \text{ L at STP}$ (1)

$V(\text{Cl}_2) \text{ at } 298 \text{ K and } 94.0 \text{ kPa} = 0.8544 \text{ L} \times (298 / 273) \times (101.3 / 94.0) = 1.01 \text{ L}$

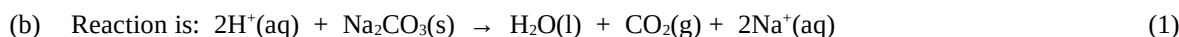
Ans: The volume of chlorine gas is 1.01 L at 25°C and 94.0 kPa. (1)

2(a) $\text{pH} = 0.716 = -\log[\text{H}^+]$ Hence, $[\text{H}^+] = 0.1923 \text{ mol L}^{-1}$ (2)

$n(\text{H}^+)_{\text{pond}} = c.V = (0.1923 \text{ mol L}^{-1})(5.26 \times 10^6 \text{ L}) = 1.00 \times 10^6 \text{ mol}$ (2)

Assuming all $\text{H}^+(\text{aq})$ in the pond came from the spilled acid,

$c(\text{HCl})_{\text{original}} = n / V = (1.090 \times 10^6 \text{ L}) / (2.00 \times 10^5 \text{ L}) = 5.00 \text{ mol L}^{-1}$ (2)



$n(\text{CO}_3^{2-}) = \frac{1}{2} n(\text{H}^+) = 5.00 \times 10^5 \text{ mol}$. (1)

Hence, $n(\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}) = 5.00 \times 10^5 \text{ mol}$. (1)

$m(\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}) = n.M = (5.00 \times 10^5 \text{ mol})(286.15 \text{ g mol}^{-1}) = 1.43 \times 10^8 \text{ g}$ (1)

Ans: The mass of hydrated sodium carbonate is $1.43 \times 10^8 \text{ g}$.



$m(\text{CO}_2) = 2.914 \text{ g}$ Hence, $n(\text{CO}_2) = m/M = (2.914 \text{ g}) / (44.01 \text{ g mol}^{-1}) = 0.06621 \text{ mol}$.

$n(\text{C}) = 0.06621 \text{ mol}$ Hence, $m(\text{C}) = n.M = (0.06621 \text{ mol})(12.01 \text{ g mol}^{-1}) = \underline{0.7952 \text{ g C}}$ (2)

$m(\text{H}_2\text{O}) = 0.9937 \text{ g}$ Hence, $n(\text{H}_2\text{O}) = m/M = (0.9937 \text{ g}) / (18.016 \text{ g mol}^{-1}) = 0.05516 \text{ mol}$.

$n(\text{H}) = 2n(\text{H}_2\text{O}) = 0.1103 \text{ mol}$. Hence, $m(\text{H}) = (0.1103 \text{ mol})(1.008 \text{ g mol}^{-1}) = \underline{0.1112 \text{ g H}}$ (2)

$m(\text{NH}_3) = 0.3759 \text{ g}$ Hence, $n(\text{NH}_3) = m/M = (0.3759 \text{ g}) / (17.034 \text{ g mol}^{-1}) = 0.02207 \text{ mol}$

Hence, $n(\text{Cl}) = n(\text{HCl}) = n(\text{NH}_3) = 0.02207 \text{ mol}$.

Hence, $m(\text{Cl}) = n.M = (0.02207 \text{ mol})(35.45 \text{ g mol}^{-1}) = \underline{0.7823 \text{ g Cl}}$ (2)

Hence, $m(\text{O}) = m(\text{sample}) - [m(\text{C}) + m(\text{H}) + m(\text{Cl})] = 2.042 \text{ g} - 1.6887 \text{ g} = 0.3533 \text{ g O}$. (1)

$n(\text{O}) = m/M = (0.3533 \text{ g}) / (16.00 \text{ g mol}^{-1}) = 0.02208 \text{ mol}$. = 1

$n(\text{C}) = 0.0662 \text{ mol}$. = 3

$n(\text{H}) = 0.1103 \text{ mol}$ = 5

$n(\text{Cl}) = 0.02207 \text{ mol}$ = 1.

Ans (a): The empirical formula is $\text{C}_3\text{H}_5\text{OCl}$

(1)

(b) 2.504 g of compound occupies 0.607 L at STP

$n(\text{compound}) = (0.607 \text{ L}) / (22.41 \text{ L mol}^{-1}) = 0.02709 \text{ mol}$.

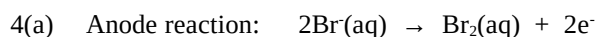
$M(\text{compound}) = m / n = (2.504 \text{ g}) / (0.02709 \text{ mol}) = 92.43 \text{ g mol}^{-1}$.

EFM = $3(\text{C}) + 5(\text{H}) + \text{O} + \text{Cl} = 92.5$

Clearly, EFM = TFM Hence, the true (molecular) formula is $\text{C}_3\text{H}_5\text{OCl}$ (2)



1-chloropropanone or 1-chloropropanal or 2-chloropropanal (1)



$n(\text{Br}_2) = \frac{1}{2} n(\text{e}^-)$ (1)

Bromine: $30 \text{ ppm} = 30 \text{ mg kg}^{-1} = 0.030 \text{ g L}^{-1}$ (1)

$m(\text{Br}_2) = (1.50 \times 10^3 \text{ L})(0.030 \text{ g L}^{-1}) = 45 \text{ g Br}_2$ (1)

Hence, $n(\text{Br}_2) = m / M = (45 \text{ g}) / (159.8 \text{ g mol}^{-1}) = 0.2816 \text{ mol Br}_2(\text{aq})$ (1)

From the balanced equation, $n(\text{e}^-) = 2n(\text{Br}_2) = 0.5632 \text{ mol}$. (1)

Coulombs = $(0.5632 \text{ mol})(96490 \text{ C mol}^{-1}) = 5.43 \times 10^4 \text{ C}$. (1)

Since $Q = It$, $t = Q / i = (5.43 \times 10^4 \text{ C}) / (1.50 \text{ A}) = 3.623 \times 10^4 \text{ s}$.

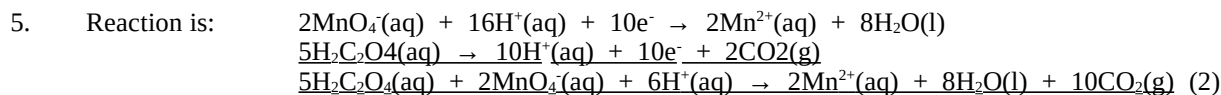
Ans (a): The time required is $3.62 \times 10^4 \text{ s}$. (1)

(b) $n(\text{NaBr}) = n(\text{Br}^-) = 2n(\text{Br}_2) = 2(0.2816 \text{ mol}) = 0.5632 \text{ mol}$. (2)

$$m(\text{NaBr}) = n.M = (0.5632 \text{ mol})(102.89 \text{ g mol}^{-1}) = 57.9 \text{ g}$$

Ans (b): The mass of NaBr consumed is 57.9 g.

(1)



Average titre volume of $\text{KMnO}_4(\text{aq})$ required = 22.45 mL

(1)

From the balanced equation, $n(\text{MnO}_4^-) = 2/5 n(\text{H}_2\text{C}_2\text{O}_4)$ (1)

$n(\text{H}_2\text{C}_2\text{O}_4) = m / M = (5.15 \text{ g}) / (126.068 \text{ g mol}^{-1}) = 0.04085 \text{ mol}$ (in 250 mL solution) (1)

Hence, $n(\text{H}_2\text{C}_2\text{O}_4)$ (in 20 mL) = $(20 / 250) (0.04085 \text{ mol}) = 3.268 \times 10^{-3} \text{ mol}$ (1)

Hence, $n(\text{MnO}_4^-)$ (in 22.45 mL) = $2/5 (3.268 \times 10^{-3} \text{ mol}) = 1.307 \times 10^{-3} \text{ mol}$ (1)

Hence, $n(\text{KMnO}_4)$ (in 22.45 mL) = $1.307 \times 10^{-3} \text{ mol}$.

Hence, $n(\text{KMnO}_4)$ (in 250 mL) = $(250 / 22.45)(1.307 \times 10^{-3} \text{ mol}) = 0.01456 \text{ mol}$. (1)

$m(\text{KMnO}_4) = n.M = (0.01456 \text{ mol})(158.04 \text{ g mol}^{-1}) = 2.3006 \text{ g}$. (1)

% $\text{KMnO}_4 = (2.3006 \text{ g} / 2.350 \text{ g}) \times 100 = 97.9 \%$

Answer: The potassium permanganate sample is 97.9% by mass potassium permanganate. (1)

Part 4: The following is not meant to be a prescriptive answer, but merely indicates what the examiner considers to be a minimum amount of information.

As Group IV elements, carbon and silicon have four electrons in their outer (valence) shell.

Carbon has the electron configuration $1s^2 2s^2 2p^2$ and silicon is $1s^2 2s^2 2p^6 3s^2 3p^2$. (2)

Each element needs to share 4 more electrons to obtain a full outer shell. (Diag. (a)). (1)

Since the sharing of electrons occurs in the second shell of carbon and the third shell of silicon, the bond strength of carbon is stronger since the electrons are closer to the nucleus and are hence attracted more strongly to the carbon atoms than to the silicon atoms, even though silicon has a higher nuclear charge. (3)

Carbon dioxide is a linear non-polar molecule containing a carbon atom double bonded to two oxygens.

Silicon dioxide is a covalent network substance in which SiO_4 groups are bonded to each other by four "bridge" oxygen atoms. (Diag. (c)). (3)

Carbon dioxide has a very low melting point and boiling point because the small nonpolar molecules are easily separated (weak dispersion force only) whereas silicon dioxide has a very high melting and boiling point because the extended covalent bonding requires considerable energy to be broken. (3)

Graphite has all carbon atoms bonded to only three neighbouring carbon atoms forming a flat hexagonal structure. It has one delocalised electron for every carbon atom and is hence a good conductor of electricity. (Diag. d(i)).

The planes of carbon atoms are held together by weak dispersion forces.

Diamond has all carbon atoms bonded to four neighbouring atoms forming a tetrahedral structure which does not conduct electricity. It is the hardest known solid. (Diag. d(ii))

Silicon carbide is similar to diamond in its structure, but has alternate silicon atoms. The C-Si bonding is weaker than the C-C bonding, so SiC is slightly softer and melts and boils at a lower temperature than diamond. (Diag. d(iii)). (6)

Silicon cannot be used to produce addition polymers because it is unable to form double bonds.

In addition polymers, double bonds between carbon atoms in the monomers break, producing an extended linear carbon-carbon chain structure. Similar silicon monomers are unable to form an extended chain structure and hence cannot form addition polymers. (Diag.(e)). (2)

