



Chemistry

Year 12

2002

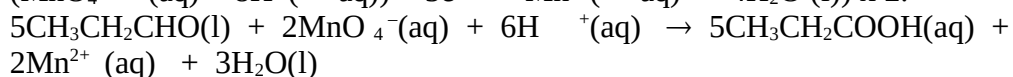
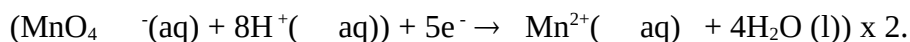
SOLUTIONS

Part 1:

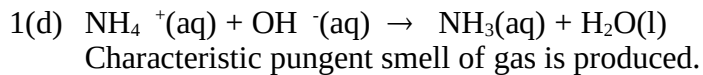
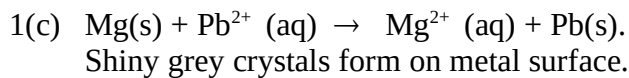
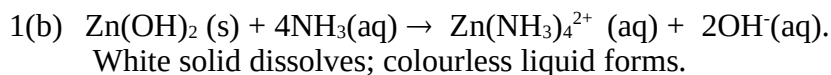
1	(b)	11	(b)	21	(c)
2	(a)	12	(d)	22	(c)
3	(a)	13	(a)	23	(a)
4	(d)	14	(b)	24	(b)
5	(b)	15	(b)	25	(d)
6	(b)	16	(c)	26	(b)
7	(a)	17	(a)	27	(c)
8	(b)	18	(a)	28	(b)
9	(b)	19	(a)	29	(d)
10	(d)	20	(a)	30	(b)

Part 2:

5



Purple colour fades to a very pale pink.



2.

Species	Structural formula	Shape	Polarity
Carbonate ion	$\left[\begin{array}{c} \text{:}\ddot{\text{O}}\text{:} \\ \times \times \\ \text{C} \\ \times \times \\ \text{:}\ddot{\text{O}}\text{:} \quad \text{:}\ddot{\text{O}}\text{:} \end{array} \right]^{2-}$	Planar triangular	Non-polar
Chlorite ion	$\left[\begin{array}{c} \text{:}\ddot{\text{O}}\text{:} \quad \times \times \quad \text{:}\ddot{\text{O}}\text{:} \\ \times \times \quad \text{Cl} \quad \times \times \\ \text{:}\ddot{\text{O}}\text{:} \quad \times \times \quad \text{:}\ddot{\text{O}}\text{:} \end{array} \right]^{-}$	Bent	Polar
Ethyne	$\text{H} \text{ : } \text{C} \text{ : } \times \times \text{ : } \text{C} \text{ : } \times \text{ : } \text{H}$	Linear	Non-polar

3(a) polythene or similar

3(b) ethene : $\text{H}_2\text{C}=\text{CH}_2$ 4(a) $\text{Mg(s)} \rightarrow \text{Mg}^{2+}(\text{aq}) + 2\text{e}^-$

4(b) Arrow from left to right (ie from Mg to Ag)

4(c) $\text{NH}_4^+(\text{aq})$ or $\text{Mg}^{2+}(\text{aq})$ 5(a) $\text{CH}_3\text{CH}_2\text{CH}(\text{CH}_3)\text{ClOHCH}_3$ 5(b) $\text{CH}_3\text{CHFCl}(\text{CH}_3)\text{CH}_2\text{COCH}_2\text{CH}_3$

5(c) sodium butoxide

5(d) pentylmethanoate

6(a)(i) A condition in a closed system when the rates of two opposite reactions have become equal.

6(a)(ii) ΔH is the heat of reaction of a system. It is defined as: $\Delta H = E_P - E_R$ where E_P is the energy of the products and E_R is the energy of the reactants.

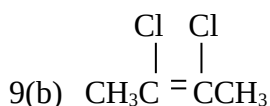
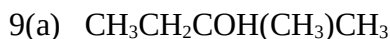
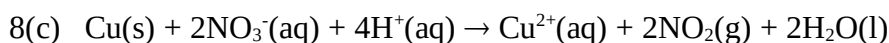
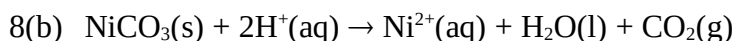
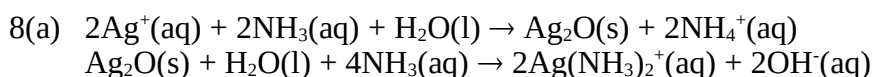
6(b)(i) Amount of products will increase

Amount of reactants will decrease

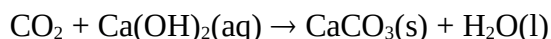
System will react to reduce pressure. It can do this by favouring the forward reaction which produces more product which has fewer molecules and hence exerts less pressure.

- 6(b)(ii) Amount of products will increase
 Amount of reactants will decrease
 System will react to increase temperature. Since forward reaction is exothermic, it will be favoured, thus producing more products and raising the temperature.

- 7(a) CS₂ or carbon disulfide.
 7(b) SO₃ or sulfur trioxide
 7(c) ethanol and butanoic acid
 7(d) CS₂ or carbon disulfide
 7(e) ethanol, carbon disulfide and propanone.



Part 3:



$n(\text{C}) = n(\text{CO}_2) = n(\text{CaCO}_3) = m/M = (4.864 \text{ g}) / (100.09 \text{ g mol}^{-1}) = 0.04860 \text{ mol}$

$m(\text{C}) = n.M = (0.04860 \text{ mol})(12.01 \text{ g mol}^{-1}) = 0.5863 \text{ g C}$

$\%C = [m(\text{C}) / m(\text{compound})] \times 100 = [(0.5863 \text{ g}) / (3.230 \text{ g})] \times 100 = 18.07\%$

$\%F = 28.6\%$ (given)

$\%Cl = 100\% - [\%C + \%F] = (100 - 46.67)\% = 53.3\%$

Consider 100 g of the compound:

$m(\text{C}) = 18.07 \text{ g} \quad n(\text{C}) = 1.50 \text{ mol} = 1$

$m(\text{F}) = 28.6 \text{ g} \quad n(\text{F}) = 1.50 \text{ mol} = 1$

$m(\text{Cl}) = 53.3 \text{ g} \quad n(\text{Cl}) = 1.50 \text{ mol} = 1$

Answer (a) The EF of the compound is CFCl

1(b) $m(\text{sample}) = 3.230 \text{ g}$

$$n(\text{sample}) = (V \text{ STP}) / (22.41 \text{ L mol}^{-1}) = (0.545 \text{ L}) / (22.41 \text{ L mol}^{-1}) = 0.0243 \text{ mol.}$$

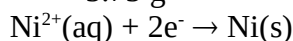
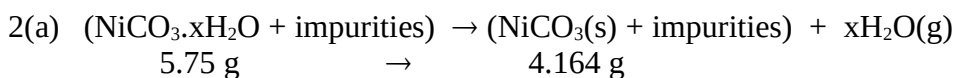
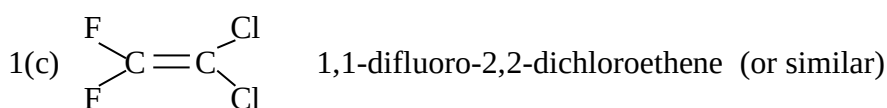
$$M(\text{compound}) = m / n = (3.230 \text{ g}) / (0.0243 \text{ mol}) = 132.9 \text{ g mol}^{-1}$$

$$\text{now, EFM} = 12.01 + 19.00 + 35.45 = 66.46$$

$$\text{Clearly, TFM} = 2(\text{EFM})$$

$$\text{TF} = 2(\text{EF}) = 2(\text{CFCl}) = \text{C}_2\text{F}_2\text{Cl}_2$$

Ans (b): The true (molecular) formula is $\text{C}_2\text{F}_2\text{Cl}_2$



$$n(\text{Ni}) = n(\text{Ni}^{2+}) = m / M = (1.707 \text{ g}) / (58.71 \text{ g mol}^{-1}) = 0.02908 \text{ mol.}$$

$$n(\text{NiCO}_3) = n(\text{Ni}) = 0.02908 \text{ mol.}$$

$$m(\text{NiCO}_3) = n.M = (0.02908 \text{ mol})(118.72 \text{ g mol}^{-1}) = 3.452 \text{ g NiCO}_3$$

Hence, 5.75 g of ore contains 3.452 g of NiCO_3

The mass of water driven off was 1.586 g.

$$n(\text{NiCO}_3) = 0.02908 \text{ mol} \quad = 1$$

$$n(\text{H}_2\text{O}) = (1.586 \text{ g}) / (18.016 \text{ g mol}^{-1}) = 0.0880 \text{ mol} \quad = 3$$

Ans(a): The formula is $\text{NiCO}_3 \cdot 3\text{H}_2\text{O}$.

2(b) The percentage of $\text{NiCO}_3 \cdot 3\text{H}_2\text{O}$ in the ore is:

$$[m(\text{NiCO}_3 \cdot 3\text{H}_2\text{O}) / (m(\text{ore}))] \times 100 = [(5.038 \text{ g}) / (5.750 \text{ g})] \times 100$$

Ans (b): The ore is 87.6% NiCO_3 by mass.

3(a) From the balanced equation:

$$n(\text{CH}_3\text{CH}_2\text{OH}) = (3/2)n(\text{Cr}_2\text{O}_7^{2-}) = 3/2(3.00 \times 10^{-5} \text{ mol})$$

$$= 4.50 \times 10^{-5} \text{ mol (in 25.0 mL of blood)}$$

Hence there is 1.80×10^{-4} mole of alcohol in 100 mL of blood

Hence there is 1.80×10^{-1} millimole of alcohol in 100 mL of blood

Ans (a): There is 1.80×10^{-1} millimole of alcohol in 100 mL of blood

3(b) 1 mole of ethanol = $(24.02 + 5.048 + 16.00)$ g = 46.07 g

1 millimole of ethanol = 0.04607 g.

1.80×10^{-1} millimole of ethanol = 8.293×10^{-3} g

% ethanol = $[(\text{mass}(\text{C}_2\text{H}_5\text{OH})) / (\text{mass}(100 \text{ mL blood}))] \times 100$

$= [(8.293 \times 10^{-3} \text{ g}) / (100 \text{ g})] \times 100 = 8.293 \times 10^{-3} \% = 0.00829\%$

Ans (b): The percentage by mass of ethanol in the blood is $8.29 \times 10^{-3} \%$

4(a) Disregard Titration 1 since the titre volume is more than 0.2 mL above the lowest titre volume.

Hence, average titre volume = $[(12.0 + 11.9 + 12.1) \text{ mL}] / 3 = \underline{12.0 \text{ mL.}}$

4(b) The reaction is: $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$

$n(\text{OH}^-) = n(\text{NaOH}) = c.V = (0.0125 \text{ mol L}^{-1})(0.020 \text{ L}) = 2.50 \times 10^{-4} \text{ mol.}$

$n(\text{H}^+)$ (in 12.0 mL diluted wine) = $2.50 \times 10^{-4} \text{ mol.}$

$n(\text{H}^+)$ (in 250 mL diluted wine) = $(250 / 12) \times (2.50 \times 10^{-4} \text{ mol}) = 5.208 \times 10^{-3} \text{ mol.}$

$n(\text{H}^+)$ (in 20 mL undiluted wine) = $5.208 \times 10^{-3} \text{ mol.}$

$n(\text{C}_4\text{H}_6\text{O}_6) = (1/2) n(\text{H}^+) = 2.604 \times 10^{-3} \text{ mol.}$

(This is because one mole of tartaric acid releases two moles of H^+ in the titration reaction!)

$c(\text{C}_4\text{H}_6\text{O}_6) = n / V = (2.604 \times 10^{-3} \text{ mol}) / (0.020 \text{ L}) = 0.1302 \text{ mol L}^{-1}$

Ans (b): The concentration of tartaric acid in the undiluted wine is $1.30 \times 10^{-1} \text{ mol L}^{-1}$

4(c) Consider 1.00 L of the original wine.

$n(\text{C}_4\text{H}_6\text{O}_6) = 0.1302 \text{ mol.}$

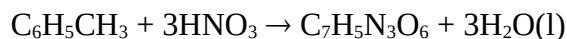
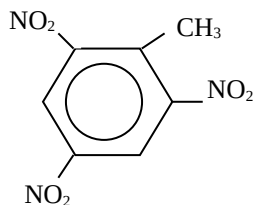
$m(\text{C}_4\text{H}_6\text{O}_6) = n.M = (0.1302 \text{ mol})(150.088 \text{ g mol}^{-1}) = 19.54 \text{ g (per litre)}$

$\%(\text{C}_4\text{H}_6\text{O}_6) = [m(\text{C}_4\text{H}_6\text{O}_6) / m(1.00 \text{ L wine})] \times 100$

$= [(19.54 \text{ g}) / (1000 \text{ g})] \times 100 = 1.95\%$

Ans (c): The wine is 1.95% by mass tartaric acid.

5(a)



Clearly, $n(\text{HNO}_3) = 3n(\text{TNT})$

$$n(\text{C}_6\text{H}_5\text{CH}_3) = n(\text{TNT})$$

$$m(\text{TNT}) = 1.00 \times 10^6 \text{ g}$$

$$n(\text{TNT}) = m/M = (1.00 \times 10^6 \text{ g}) / (227.14 \text{ g mol}^{-1}) = 4403 \text{ mol.}$$

$$m(\text{C}_6\text{H}_5\text{CH}_3) = n.M = (4403 \text{ mol})(92.134 \text{ g mol}^{-1}) = 4.06 \times 10^5 \text{ g.}$$

Ans (b) (i): 4.06×10^5 g of toluene are required.

$$n(\text{HNO}_3) = 3n(\text{TNT}) = 3n(\text{toluene}) = 3(4403 \text{ mol}) = 13209 \text{ mol.}$$

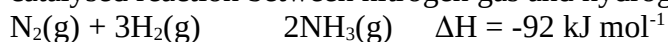
$$m(\text{HNO}_3) = n.M = (13209 \text{ mol})(63.018 \text{ g mol}^{-1}) = 832405 \text{ g.}$$

Ans (b) (ii) = 8.32×10^5 g of nitric acid are required.

Part 4 These answers are given as a guide only and are not meant to be an exhaustive or prescriptive indication of acceptable answers.

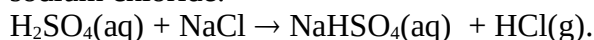
1. Ammonia and Hydrogen chloride

Both gases are synthesised from their constituent elements. Ammonia is prepared by the catalysed reaction between nitrogen gas and hydrogen in the Haber process:



Hydrogen chloride is prepared industrially by the reaction between hydrogen gas and chlorine gas:

$\text{H}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow 2\text{HCl}(\text{g})$ or by the reaction between concentrated sulfuric acid and solid sodium chloride:



The molecules of both gases are polar due to polar bonds within the molecules and the asymmetric shape of the molecules. Ammonia is a slightly more polar molecule than hydrogen chloride, due to the greater bond polarity of the hydrogen - nitrogen bond compared with the hydrogen - chlorine bond.

Both ammonia and hydrogen chloride are extremely soluble in water. This is due to the high degree of interaction between the polar solute molecules and the polar solvent (water) molecules.

The aqueous solutions of these gases are known as ammonia solution and hydrochloric acid respectively.

The principal difference between their solutions is that ammonia molecules are only very slightly ionised :

$\text{NH}_3(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{NH}_4^+(\text{aq}) + \text{OH}^-(\text{aq})$. The principal species in ammonia solution is ammonia molecules. Only one ammonia molecule in about 10^5 tends to ionise (by accepting a proton) in aqueous solution. For this reason, ammonia solutions are only **weak** bases because they only slightly increase the hydroxide ion concentration.

Hydrochloric acid, on the other hand is a **strong** acid because hydrogen chloride gas molecules in aqueous solution are almost completely ionised: $\text{HCl}(\text{aq}) = \text{H}^+(\text{aq}) + \text{Cl}^-(\text{aq})$. As a strong acid, hydrochloric acid is widely used in industry to clean metals and in swimming pools to control pH level, and in cleaning bricks. Ammonia solution is used directly as a fertiliser, household and industrial cleaner, and in the manufacture of ammonium nitrate and ammonium sulfate.

2. Structure and properties of substances

Substance A is most likely to be a polar covalent molecular substance. Its moderately high boiling point suggests a large molecule which does not ionise in water solution as evidenced by the lack of electrical conductivity of the solution. The fact that it dissolves in water suggests that the molecule is polar. The fact that its aqueous solution is a non-electrolyte indicates that the molecule does not ionise. Covalent molecular substances do not conduct electricity in either the solid or molten state because the molecules do not ionise, and there are no delocalised electrons present in either state. Due to the description "brittle white solid", substance A could be sugar $\text{C}_{12}\text{H}_{22}\text{O}_{11}$ or a similar sized molecule with -OH groups attached.

Substance B is most likely to be a non-polar covalent molecular substance. Its boiling point of 100°C indicates it is covalent molecular in structure. Since substance B does not dissolve in water, its molecules are probably non-polar. As a colourless liquid, it could be a liquid hydrocarbon with a chain length of about seven carbon atoms. It is noted that heptane, C_7H_{16} boils at about 100°C .

Substance C Its conductivity only when molten indicates that substance C is definitely ionic. This is further supported by its relatively high boiling point and the fact that it is a strong electrolyte. The description "brittle white solid" could refer to a salt. Its solubility in water could indicate a nitrate of any metal, a chloride or sulfate of most metals or a carbonate of a Group I or II metal or ammonium.

Substance D The appearance of the substance and its conductivity when solid indicate that it is a metal. Only metals and graphite conduct in the solid state, and graphite is ruled out because the substance has a silvery, not black, appearance! The boiling point of 1800°C does not indicate any particular metal as many transition metals have high boiling points and a silvery appearance, but the metal is definitely not copper or gold, and the fact that it is a solid at room temperature means that it is not mercury! Metals consist of an array of positive ions and delocalised electrons in both the solid and molten states