Year 12 Chemistry Examination Solutions Semester 1 2001

Multiple Choice

1A 2A 3B 4C 5A 6B 7D 8C 9A 10C 11B 12C
13A 14B 15A 16D 17D 18B 19C 20B 21D 22A
23A 24B 25D 26B 27B 28C

Short Answer

Question 1

Write *ionic* equations to show why:

(i) a solution of $NaCH_3COO$ has a pH higher than 7; [2 marks]

makes pH > 7.

$CH_3COO^-(aq) + H_2O(l) \rightleftharpoons CH_3COOH(aq) + OH^-(aq)$

(ii) a solution of NH_4Cl has a pH lower than 7. [2 marks]

$NH_4^+(aq) + H_2O(l) \rightleftharpoons NH_3(aq) + H_3O^+(aq)$

makes pH < 7.

Question 2

(i)

Cell 1: $\cancel{2}Ag^+(aq) \cancel{e^-} \rightarrow \cancel{2}Ag(s)$ $E^\circ = 0.80\,V$

$Mg(s) \rightarrow Mg^{2+}(aq) + \cancel{2e^-}$ $E^\circ = 2.37\,V$

∴ $Mg(s) + 2Ag^+(aq) \rightarrow 2Ag(s) + Mg^{2+}(aq)$

∴ Mg electrode dissolves.

Ag electrode has deposits of Ag formed.

(ii)

$2Fe^{3+}(aq) + \cancel{2e^-} \rightleftharpoons 2Fe^{2+}(aq)$ $E^\circ = 0.77\,V$

$Cu(s) \rightarrow \cancel{2e^-} + Cu^{2+}(aq)$ $E^\circ = -0.34\,V$

$2Fe^{3+}(aq) + Cu(s) \rightarrow 2Fe^{2+}(aq) + Cu^{2+}$

Iron solution will turn green

Copper solution will turn deeper blue.

(iii)

$E^\circ_{cell} = 0.80 + 2.37 = 3.17\ V$

(iv)

The materials change and so lose their ability to donate and accept electrons respectively to the other half cell

(v)

To prevent polarisation.

To have a complete circuit

(vi)

Fe^{3+} is the oxidising agent. Oxidation occurs at the Cu electrode which is the anode.

Question 3

(i) +5

(ii) C in $(COOH)_2$

(iii) $(COOH)_2$ (aq) ----> $2CO_2$ (g) + $2H^+$ (aq) + 2e

(iv) 6e + $6H^+$ (aq) + BrO_3^- (aq) ----> Br^- (aq) + $3H_2O$(l)

(v)

$3(COOH)_2(aq) \rightarrow 6CO_2(g) + \cancel{6H^+} + \cancel{6e^-}$

$\cancel{6e^-} + \cancel{6H^+} + BrO_3^-(aq) \rightarrow Br^-(aq) + 3H_2O$

$3(COOH)_2(aq) + BrO_3^-(aq) \rightarrow 6CO_2(g) + Br^-(aq) + 3H_2O(l)$

Question 4

(i)

Equation $Cu^{2+}(aq) + Mg(s) \rightarrow Cu(s) + Mg^{2+}(aq)$

Observation Magnesium dissolves slowly. Blue solution begins to pale. Brown copper solid formed.

(ii)

Equation $2NO_2(g) \rightleftharpoons N_2O_4(g)$ + heat.

Observation Mixture becomes more pale.

(iii)

Equation $2CrO_4^{2-}(aq) + 2H^+(aq) \rightleftharpoons Cr_2O_7^{2-}(aq) + H_2O(l)$ (Yellow → Orange)

Observation Solution will turn orange.

(iv)

Equation: 2HCl(aq) + Na_2S(aq) ---> 2NaCl (aq) + H_2S (g)

Observation: putrid smell, bubbles

(v)

Equation $2HCl(aq) + Na_2SO_3(aq) \rightarrow 2NaCl(aq) + SO_2(g) + H_2O(l)$

Observation Putrid Smell, Bubbles

Question 5

(i) Which compound is a strong acid? HNO_3

(ii) Which compound is a weak acid? CH_3COOH

(iii) Which **two** compounds are soluble salts? Na_2SO_4 + $Fe(NO_3)_3$ (or KOH)

(iv) Which **two** compounds are insoluble salts? $CaCO_3$ + AgCl

(v) Which compound is a strong base? KOH

(vi) Which compound is a weak base? NH_3

(vii) Which compound is an acidic oxide? SO_3

(viii) Which compound is a basic oxide? MgO

(ix) Which **two** compounds dissolve in water to give weakly conducting solutions? CH_3COOH + NH_3

(x) Which compound produces no ions when it dissolves in water? NONE

(xi) Which **two** compounds react with each other to produce iron(III) hydroxide? $Fe(NO_3)_3$ and KOH.

Question 6

(i) C_3H_7OH (l) + CH_3COOH (l) $\rightleftharpoons$ $CH_3COOC_3H_7$ (l) + H_2O (l)

K_{eq} = 1

(ii) $2H_2$ (g) + O_2 (g) $\rightleftharpoons$ $2H_2O$ (g)

$K_{eq} = [H_2O(g)]^2 / [H_2(g)]^2 [O_2(g)]$

(iii) NH_4Cl (s) $\rightleftharpoons$ NH_3 (g) + HCl (g)

$K_{eq} = [NH_3(g)][HCl(g)]$

(iv) H_2O (l) $\rightleftharpoons$ H^+ (aq) + OH^- (aq)

$K_{eq} = [H^+][OH^-]$

(v) $C_{12}H_{22}O_{11}$ (s) $\rightleftharpoons$ $C_{12}H_{22}O_{11}$ (aq)

$K_{eq} = [C_{12}H_{22}O_{11}(aq)]$

(vi) 4Al (s) + $3O_2$ (g) + $6H_2O$ (l) $\rightleftharpoons$ $4Al(OH)_3$ (s)

$K_{eq} = \frac{1}{[O_2]^3}$

Question 7

(i) increased pressure products

(ii) increased temperature reactants

(iii) addition of hydrogen products

(iv) removal of the product CH_3OH products

Question 8

(i)

$\cancel{Ba^{2+}(aq)} + 2OH^-(aq) + H^+(aq) + \cancel{2NO_3^-(aq)} \rightarrow \cancel{Ba^{2+}(aq)} + \cancel{2NO_3^-(aq)} + H_2O(l)$

$2OH^-(aq) + 2H^+(aq) \rightarrow 2H_2O(l)$

$OH^-_{(aq)} + H^+_{(aq)} \rightarrow H_2O(l)$

(ii)

$Ba^{2+}(aq) + \cancel{2Cl^-(aq)} + \cancel{2Na^+(aq)} + CO_3^{2-}(aq) \rightarrow BaCO_3(s) + \cancel{2Na^+(aq)} + \cancel{2Cl^-(aq)}$

$Ba^{2+}(aq) + CO_3^{2-}(aq) \rightarrow BaCO_3(s)$

(iii)

$\cancel{3Na^+(aq)} + 2PO_4^{3-}(aq) + 3Ni^{2+}(aq) + \cancel{2NO_3^-(aq)} \rightarrow Ni_3(PO_4)_2(s) + \cancel{3Na^+(aq)} + \cancel{2NO_3^-(aq)}$

$2PO_4^{3-}(aq) + 3Ni^{2+}(aq) \rightarrow Ni_3(PO_4)_2(s)$

(iv)

$\cancel{Na^+(aq)} + 2OH^-(aq) + Fe^{2+}(aq) + \cancel{2Cl^-(aq)} \rightarrow Fe(OH)_2(s) + \cancel{Na^+(aq)} + \cancel{2Cl^-(aq)}$

$Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$

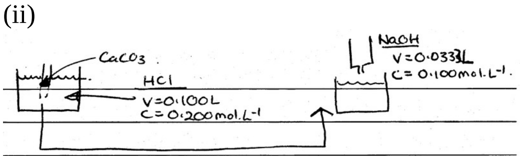
Calculations

Question 1

(i)

$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

(ii)



$n(NaOH) = c \times V$

$= 0.100 \times 0.0333$

$= 3.33 \times 10^{-3}$ moles

(iii)

remaining

$n(HCl) = n(NaOH) = 3.33 \times 10^{-3}$ moles

$n(HCl\ start) = C(HCl\ start) \times V(HCl)$

$= 0.200 \times 0.100$

$= 0.020$ moles

$n(HCl\ used) = n(HCl\ start) - n(HCl\ remaining)$

$= 0.020 - (3.33 \times 10^{-3})$

$= 0.01667 = 1.67 \times 10^{-2}$ moles

(iv)

$2HCl(aq) + CaCO_3(s) \rightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

$n(CaCO_3) = \frac{n(HCl\ used)}{2} = \frac{0.01667}{2}$

$= 8.335 \times 10^{-3}$ moles

$m(CaCO_3) = n(CaCO_3) \times M(CaCO_3)$

$= 8.335 \times 10^{-3} \times 100$

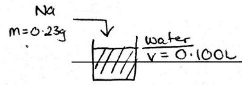
$= 0.834g$

Question 2

(i)

$2Na(s) + 2H_2O(l) \rightarrow H_2(g) + 2NaOH(aq)$

(ii)



$n(Na) = \frac{m(Na)}{M(Na)} = \frac{0.23}{23} = 0.01$ moles

$n(NaOH) = n(Na) = 0.01$ moles

$n(OH^-) = n(NaOH) = 0.01$ moles

$[OH^-] = \frac{n(OH^-)}{V} = \frac{0.01}{0.100} = 0.1\ mol.L^{-1}$

$[OH^-][H^+] = 10^{-14}$

$\therefore [H^+] = \frac{10^{-14}}{[OH^-]} = \frac{10^{-14}}{0.1} = 10^{-13}$

$pH = -\log[H^+]$

$= -\log[10^{-13}]$

$= 13$

Question 3

$n(HNO_3) = \frac{m(HNO_3)}{M(HNO_3)} = \frac{75.0}{63}$

$= 1.1905$ moles.

1 mole HNO_3 comes from 3/2 moles of $NO_2(g)$.

3/2 moles of NO_2 comes from 3/2 moles of NO.

3/2 moles of NO comes from 3/2 moles of NH_3.

So 1 mole HNO_3 comes from 3/2 moles of NH_3

$\therefore$ 1.1905 moles " " " $(1.1905 \times 3/2)$ moles NH_3

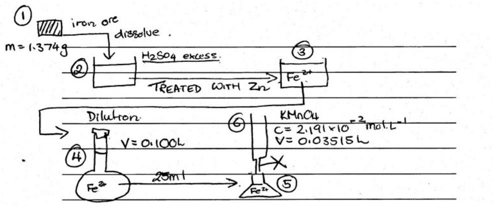
$= 1.7857$ moles NH_3

$m(NH_3) = n(NH_3) \times M(NH_3)$

$= 1.7857 \times 17$

$= 30.4g$

Question 4



Need mass of iron can be extracted from ~~or~~ 1.5t ore.

$n(KMnO_4\ at\ 6) = c \times V = 2.191 \times 10^{-2} \times 0.03515$

$= 7.701365 \times 10^{-4}$ moles.

$MnO_4^-(aq) + 8H^+(aq) + \cancel{5e^-} \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$

$5Fe^{2+}_{(aq)} \rightarrow 5Fe^{3+}_{(aq)} + \cancel{5e^-}$

$MnO_4^-(aq) + 5Fe^{2+} + 8H^+(aq) \rightarrow Mn^{2+}(aq) + 4H_2O(l) + 5Fe^{3+}(aq)$

$n(MnO_4^-\ at\ 6) = n(KMnO_4) = 7.701365 \times 10^{-4}$

$n(Fe^{2+}\ at\ 5) = 5 \times n(MnO_4^-) = 5 \times 7.701365 \times 10^{-4}$

$= 3.8506825 \times 10^{-3}$.

$c(Fe^{2+}\ at\ 4) = \frac{n(Fe^{2+}\ at\ 5)}{0.025} = 3.8506825 \times 10^{-3} / 0.025$

$= 0.1540273\ mol.L^{-1}$.

$n(Fe^{2+}\ at\ 4) = c \times V = 0.1540273 \times 0.100$

$= 0.0154027$ moles

$n(Fe^{2+}\ at\ 3) = n(Fe^{2+}\ at\ 4) = 0.0154027$ moles

$n(Fe\ in\ ore) = n(Fe^{2+}\ at\ 3) = 0.0154027$ moles

$m(ore) = 1.374g$

$m(Fe\ in\ ore) = n(Fe) \times M(Fe)$

$= 0.0154027 \times 55.85$

$= 0.86024g$. 1

in 1.374g of ore we have 0.860249g Fe

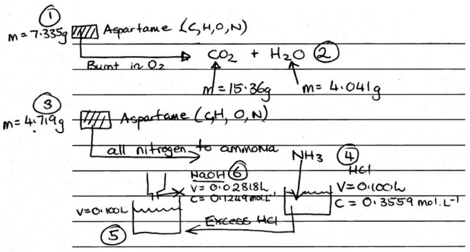
$\therefore \%(Fe\ in\ ore) = \frac{0.86024}{1.374} \times 100 = 62.61\%$

$\therefore$ In 1.5 tonne ore, $m(Fe) = \frac{62.61}{100} . 5$

$= 0.9391t$

$= 939.1kg$

Question 5



NEED EMPIRICAL FORMULA OF ASPARTAME.

$n(CO_2 \text{ at } 2) = \frac{m}{M} = 15.36/44 = 0.3491$ moles

$n(C \text{ at } 2) = n(CO_2) = 0.3491$ moles

$n(C \text{ at } 1) = n(C \text{ at } 2) = 0.3491$ moles

$n(H_2O \text{ at } 2) = m/M = 4.041/18 = 0.2245$ moles

$n(H \text{ at } 1) = 2 \times n(H_2O \text{ at } 2) = 2 \times 0.2245 = 0.4490$ moles

$m(C \text{ at } 1) = n(C \text{ at } 1) \times M(C) = 0.3491 \times 12 = 4.1891g$

$\boxed{\%(C) = 4.1891/7.335 \times 100 = 57.11\%}$

$m(H \text{ at } 1) = n(H \text{ at } 1) \times M = 0.4490 \times 1 = 0.4490g$

$\boxed{\%(H) = \frac{0.4490}{7.335} \times 100 = 6.12\%}$

$n(NaOH \text{ at } 6) = C \times V = 0.1249 \times 0.02818L = 3.5197 \times 10^{-3}$ moles.

$n(HCl) = n(NaOH) = 3.5197 \times 10^{-3}$ moles 1/2

This is the ~~excess~~ remaining HCl.

$n(HCl \text{ at } 4) = C \times V = 0.3559 \times 0.100 = 0.03559$ moles

$\therefore n(HCl \text{ reacting with } NH_3) = 0.03559 - (3.5197 \times 10^{-3})$

$= 0.03208$ moles

$HCl + NH_3 \rightarrow NH_4Cl$.

$n(NH_3) = n(HCl) = 0.03208$ moles

$n(N) = n(NH_3) = 0.03208$ moles

$m(N) = n(N) \times M(N) = 0.03208 \times 14 = 0.44912g$

$\boxed{\%(N) = 0.44912/4.719 \times 100 = 9.52\%}$

$\boxed{\%(O) = 100 - 57.1 - 6.12 - 9.52 = 27.26\%}$

	C	H	O	N
in 100g	57.1g	6.12g	27.3g	9.5g
n(m/M)	4.758	6.12	1.71	0.679
ratio	7	9	2.5	1
whole ratio	14	18	5	2

Empirical Formula $C_{14}H_{18}O_5N_2$

Essay

Question 1

(R. Perry's Essay)

- Ammonia is produced by the Haber Process, as mentioned.
- Each item in the Haber process has a special purpose.
- The Haber process is the production of ammonia from hydrogen and Nitrogen gases.
- The reaction: $3H_{2(g)} + N_{2(g)} \rightleftharpoons 2NH_{3(g)}$ $\Delta H = -92kJ$ 2
- The process begins with N_2 & H_2 gas being pumped into a pressure chamber. ~~As~~ By Le'Chatlier's principle, the Formation of NH_3 will be favoured at high pressures, but too high will present too great a danger and too expensive. 350 atm. is an acceptable pressure. Also, it is difficult & expensive to maintain high pressures so 350atm is acceptable. 2
- ~~After~~ The next step in the process is to pump 1 the gas through a heating coil onto an iron catalyst. Again, due to Le'chatlier's principle, as the reaction taking place is exothermic, lower temperatures would yield the most 2 product, however at low temperatures the process is far too slow. To compromise, 2 temperatures of 500°C are maintained. It would also be too expensive to keep it at very low temperatures, so 500°C is considered acceptable.
- The catalyst acts in it's usual manner, providing an alternate pathway for the reaction to take place. However, it is important to note that the catalyst reduces the activation energies for both the forward & reverse 2 reactions. In knowing this, it is clear that the catalyst does NOT assist ~~in~~ yield production; it simply allows equilibrium to be reached quicker, therefore saving money.
- After the catalyst, there is a heat exchanger. This aids in removing kinetic energy from the gases by ~~so~~ decreasing temperature, ∴ reducing the chance of the newly formed NH_3 from going back to reactant form.
- It then travels along a tube, & it 1 goes through a cooling tube to liquify the NH_3, making it easier to collect in order to separate from unused $N_2 + H_2$. It travels to a pond, & the uncombined
- N_2 & H_2 are pumped through the process again.

This is not essay format.

Question 2

(R. Marshall's Essay)

Chlorine is an important element and has several properties that could aid a chemistry teacher in their teaching methods.

If I was a chemistry teacher I would first introduce my class to the production of Cl gas through it redox reaction 1.5

$MnO_{2(s)} + 4H^+_{(aq)} + 2Cl^-_{(aq)} \rightarrow Mn^{2+}_{(aq)} + Cl_{2(g)} + 2H_2O_{(l)}$

This reaction could also help to explain the use of Permanganate as a common Oxidising agent in the use of redox titrations as it liberates electrons readily.

~~You could also use the process of bleaching to help~~ Chlorine can also be prepared by the reaction of Potassium Permanganate with concentred HCl

$2MnO_4^- + 16H^+ + 10Cl^- \rightarrow 2Mn^{2+} + 8H_2O + 5Cl_2$

This again can be ~~the~~ used to help

explain how to balance redox ~~et~~ equations and also explain ~~what~~ what occurs when oxidation and reduction ~~occurs~~ takes place. We can see here that Cl ions are ~~gaining~~ losing electrons to form ~~a~~ the Chloride gas in which we require. Evidently we also see permanganate gaining these electrons. Thus, I would explain to my chemistry students that the Cl ions are being oxidised in this production of chloride and simultaneously permanganate is ~~to~~ being reduced. This would also help to explain that ~~chlorine~~ redox reactions must occur simultaneously and are virtually interdependent. ✓ 1.5

In helping to explain acids and bases by using Chlorine as an element I would show the reactions of non-metals and metals to produce salts for example

$$2Na_{(s)} + Cl_{2(g)} \rightarrow 2NaCl_{(s)}$$

I would also show the reaction of ~~a~~ dilute ~~chlorine~~ bases disproportionate Chlorine into chloride and Hypochlorite ions. Not only would this teach them ✓ 1.5 the acid base reaction of non metals and bases but also teach them what is meant by the term disproportionations. Chloride can be seen both oxidising and reducing, I think this particular reaction would aid in my teaching of the term disproportionation.

$$Cl_{2(aq)} + H_2O_{(l)} \rightarrow Cl^-_{(aq)} + ClO^-_{(aq)} + H_2O_{(l)}$$

The reaction with chlorine and water would further more aid in class 1.5 discussions involving acids and bases. I could use this equation below to show that water can act as an acid where it donates protons and a base where it accepts protons according to the Browsted Lowry theory.

$$Cl_{2(aq)} + H_2O_{(l)} \rightleftharpoons H^+_{(aq)} + Cl^-_{(aq)} + HClO_{(aq)}$$

Here we see water acting as the acid according to the Browsted Lowry theory as it is ~~accepting~~ donating H ions.

This particular reaction also exists at equilibrium and~~s~~ so I could use it 1.5 to initiate my discussion on equilibrium.

Finally, I would teach my chemistry students the industrial processes ~~that~~ that involve the use of Chlorine as 1.5 chemistry largely involves background on industrial and chemical processes. I would begin by discussing the involvement of Chlorine in Bleaching. "Bleaching is the conversion of colour~~ss~~ed dyes to colourless products achieved by oxidising the dyes with chlorine or hypochlorites, enhanced if HClO is formed in Solution. The reaction is as follows" I would say as I wrote it on the white board

$$HClO_{(aq)} + H^+_{(aq)} + 2e^- \rightarrow Cl^-_{(aq)} + H_2O_{(l)}$$

"Chlorine Solution which produces HClO acid by the reaction

$$Cl_{2(aq)} + H_2O_{(l)} \rightarrow H^+_{(aq)} + Cl^-_{(aq)} + HClO$$

The reaction between the acid and the bleaching agent generates HCl" "Evidently HClO Bleaches the fabric by oxidation then the fabric is washed"

I could also go into water purification using chlorine as an extension. 1.5

Overall, I think a teacher would benefit greatly from the use of Chlorine to initiate discussions involving reaction between acids and bases, redox reactions and industrial processes. ✓