Our country, our future

525/1

S6 CHEMISTRY

Exam 22

PAPER 1

DURATION: 2 HOUR 45 MINUTES

Instructions to candidates:

1. Answer all questions in section A and six questions in section B
2. All questions are to be answered in the spaces provided

FOR EXAMINER'S USE ONLY

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total

SECTION A (46 MARKS)

Answer all questions in this section

1. (a) Complete the following equation for the decay of bismuth.

$^{214}_{83}Bi \rightarrow {}^{0}_{-1}e + {}^{214}_{84}P$ ..... (1 mark)

(b) The half life of bismuth is 19.7 minutes. Determine the time taken for 43% by mass of bismuth to decay. (3 marks)

Let decay constant be k

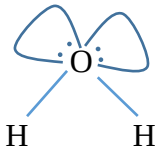
k = $\frac{In2}{19.7}\ min^{-1}$

$In\ \frac{100}{(100-43)}$ = kt = $\frac{In2}{19.7}t$

t = 15. 97min

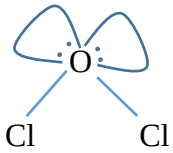
2. Draw the shape and name the structure of each of the following species

(i) H_2O (1 mark)



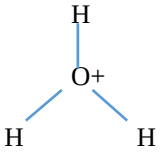
V-shape

(ii) Cl_2O (1 mark)



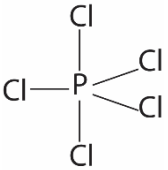
V-shape

(iii) H_3O^+ (1 mark)



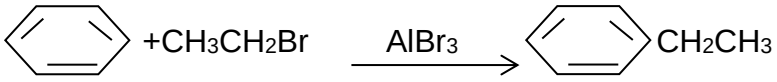
trigonal planar

(iv) PCl_5 (1 mark)

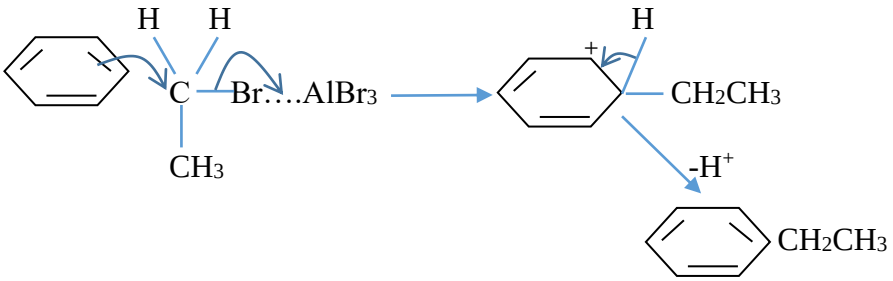


triangular bipyramidal

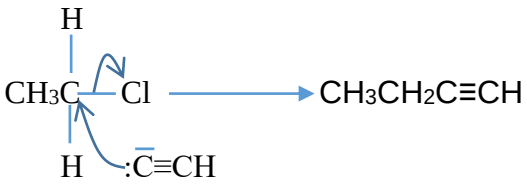
3. Complete the following equations and in each case write a mechanism for the reaction

(a) 

(4 marks)



(b) $CH_3CH_2Cl + HC \equiv CNa \xrightarrow{Liq.NH_3} CH_3CH_2C\equiv CH$ (2 marks)



4. Write an ionic equation for the reaction between sodium hydroxide and

(a) Silicon IV oxide (1 ½ marks)

$SiO_2\ (s) + 2OH^-(aq) \rightarrow SiO_3^{2-}(aq) + H_2O\ (l)$

(b) Aluminium III oxide (1 ½ marks)

$Al_2O_3(s) + 2OH^-(aq) \rightarrow 2AlO_2^-(aq) + H_2O(l)$

(c) Lead II oxide (1 ½ marks)

$PbO(s) + 2OH^-(aq) \rightarrow PbO_2^{2-}(aq)$

5. 2.910 of a compound Q was dissolved in 160g of ethanol. The boiling point of the solution was 78.97°C while that of pure ethanol was 78.8°C. (Kb for ethanol is1.15°C for 1 mole in 1000g). Calculate the molecular mass of Q in ethanol

Solution

Mass of Q in 1000g of ethanol = $\frac{2.91\ x\ 1000}{160}$ = 18.1875g

Boiling point elevation = 78.97 - 78.8 = 0.17^0C
Molecular mass
0.17^0C is caused by 18.1875g
1.15^0C is caused by RFM = $\frac{18.1875\ x\ 1.15}{0.17}$ = 123

∴ RFM of Q = 123

6. (a) A crystalline solid T dissolved in water to give a pink solution. Addition of excess aqueous sodium hydroxide produced a dirty white precipitate which rapidly turned brown on standing. When nitric acid was added to the solution of T followed by sodium bismuthate solution, the solution changed from pink to purple.

(b) Write

(i) the equation for the reaction that took place when sodium hydroxide was added to the solution. (1 ½ marks)

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

(ii) the formula of the species responsible for the purple colour (1 mark)

MnO_4^-

(iii) equation for the reaction leading to the formation of the brown solid (1 ½ marks)

$4Mn(OH)_2\ (s) + O_2(g) \rightarrow Mn_2O_3\ (s) + H_2O(l)$

7. (a) Define the term 'solubility of a salt

This is the mass of a solid that saturates 100g of solvent at a given temperature.

(b) The solubility of calcium phosphate is 0.0011g per 100g of water at 25°C. Calculate the solubility product of calcium phosphate at 25°C (5 marks)

Solution
Concentration of calcium phosphate per dm^3 = $\frac{0.0011\ x\ 1000}{100}$ = $0.011gdm^{-3}$

Formula mass of calcium phosphate, $Ca_2(PO_4)_2$ = (40.1 x3 +2(31+16 x 4))
= 310.3
Molarity of calcium phosphate = $\frac{0.011}{310.3}$ = 3.5 x $10^{-5}$$moldm^{-3}$
$[Ca^{2+}]$ = 3 x 3.5 x 10^{-5} = 1.06 x 10^{-4} = $moldm^{-3}$
$[PO_4^{3-}]$ = 2 x 3.5 x 10^{-5} = 7.09 x $10^{-5}$$moldm^{-3}$
Ksp = $[Ca^{2+}]^3[PO_4^{3-}]^2$

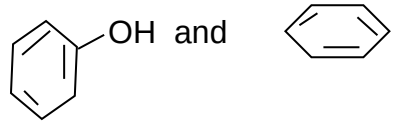
$= (1.06 \times 10^{-4})^3(7.09 \times 10^{-5})^2 = 6.0 \times 10^{-21} mol^5 dm^{-15}$

8. Name the reagent the can be used to distinguish between the following pairs of compounds. In each case, state what would be observed if the reagent is treated separately with each pair of compounds

(a) HCOOH and CH_3COOH
Reagent: ammoniacal silver nitrate

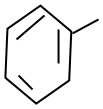
Observation
HCOOH = silver mirror

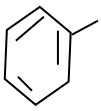
CH_3COOH – no observable change

(b)  and 

Reagent: neutral iron (III) chloride (1 mark)

Observation (2 marks)

 OH purple solution

 CH_2OH no observable change

9. $200cm^3$ of an aqueous solution containing 40g of x was shaken once with 100 cm_3 of ether

(a) Calculate the mass of X extracted by ether. (The distribution coefficient KD, of X between ether and water is 4) (2 marks)

Let the mass extracted be k

$K_D = \frac{\frac{k}{100}}{\frac{(40-k)}{200}} = 4$

k = 26.7g

(b) Calculate the mass of X that would be extracted by shaking the solution twice with $50cm^3$ of ether. (4 marks)

Solution

Let the mass extracted by the first 50cm3 of ether be q

$K_D = \frac{\frac{q}{50}}{\frac{(40-q)}{200}} = 4$

q = 20g

mass of X that remained in 200cm^3 of water = 40 – 20 = 20g

let the mass extracted by the second 50cm3 of ether be p

$K_D = \frac{\frac{p}{50}}{\frac{(20-p)}{200}} = 4$

p = 10g

total mass extracted = 20 + 10 = 30g

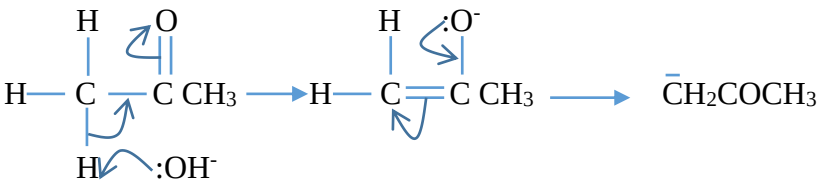
SECTION B (54 MARKS)

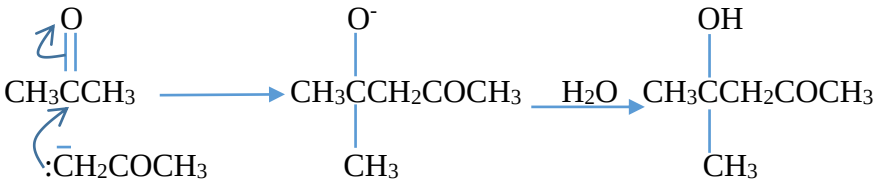
Attempt only six questions from this section

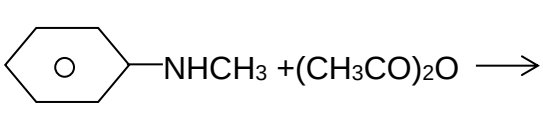
10. Complete the following reactions and suggest their mechanisms

(a) $2(CH_3)_2CO \xrightarrow{\text{dil. NaOH}} CH_3C(OH)(CH_2COCH_3)(CH_3)$ (3 ½ marks)

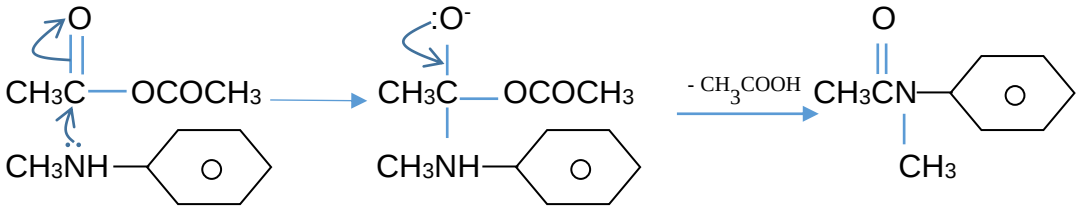
Mechanism

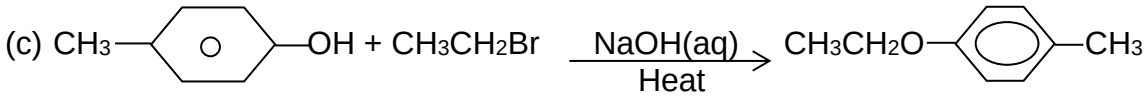




(b) 

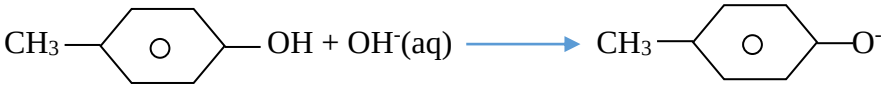
Mechanism

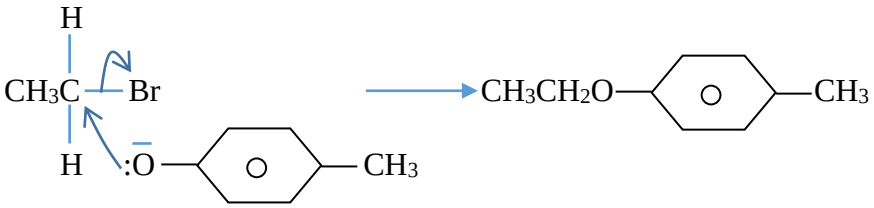


(c) 

(2 ½ marks)

Mechanism





11. (a) A piece of clean magnesium ribbon was added to a solution of iron III chloride solution

(i) State what was observed

A brown solution turns green to grey crystals and colourless solution

(ii) Explain your observation in a (i) above

Brown Fe^{3+} is reduced to green Fe^{2+} then to grey iron

(iii) Write stepwise equations for the reactions that took place (4 marks)

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

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

(b) State what would be observed if a few drops of iron III chloride was added to the solution of the following:

(i) sodium acetate (1 mark)

Red solution formed

(ii) phenol (½ mark)

Purple solution

12. (a) Write an equation for the

(i) acid dissociation constant, Ka, for ethanoic acid (2 marks)

$$K_a = \frac{[CH_3COO^-][H^+]}{[H_3COOH]}$$

(ii) relationship between acid dissociation constant, Ka, and degree of ionisation of an acid (1 mark)

$$K_a = \alpha^2 C$$

(b) The electrolytic conductivity of a 1.6×10^{-2} M CH_3COOH at 20°C is 1.96×10^{-2} Sm^{-1} and its molar conductivity at infinite dilution is 3.5×10^{-2} $Sm^2 mol^{-1}$. Calculate

(i) The molar conductivity of the ethanoic acid at 20°C (2 marks)

$1.6 \times 10^{-2}M = 16 molm^{-3}$

$$\Lambda_c = \frac{K}{C} = \frac{1.96\ x\ 10^{-2}}{16} = 0.001225 Sm^2 mol^{-1}$$

(ii) The degree of ionisation of the acid at 20°C (1 mark)

$$\alpha = \frac{\Lambda_c}{\Lambda_0} = \frac{0.001225}{0.035} = 0.035$$

(iii) The pH of the acid

$[H^+] = \alpha C = 0.035 \times 1.6 \times 10^{-2} = 5.6 \times 10^{-4} moldm^{-3}$

$pH = -\log[H^+] = 3.2$

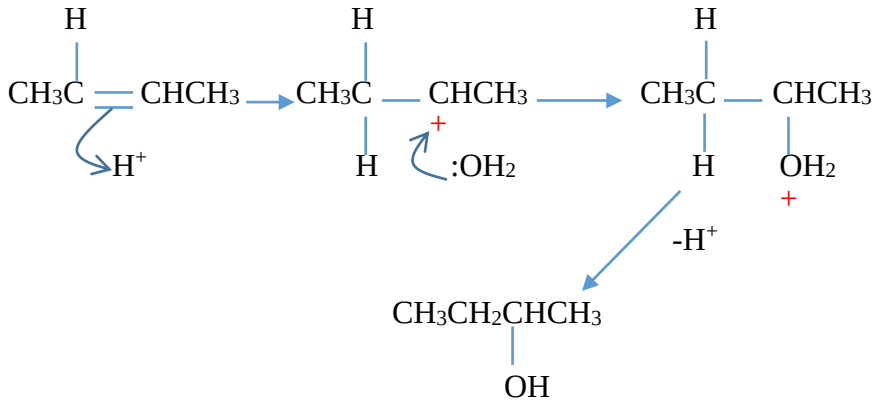
(c) Besides concentration, state one other factor that can affect the pH of the acid

(1 mark)

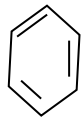
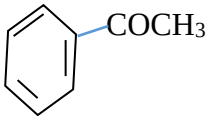
Temperature

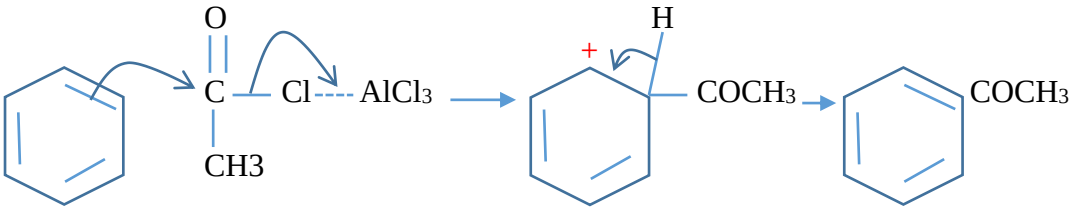
13. Complete the following equations and in each case write the accepted mechanism for the reaction

(a) $CH_3CH = CHCH_3 \xrightarrow{H^+/H_2O} CH_3CH_2CH(OH)CH_3$

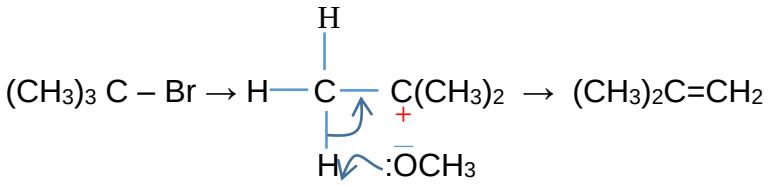


(3 marks)

(c)  + $CH_3COCl \xrightarrow{AlCl_3}$ 



(c) $(CH_3)_3C – Br + CH_3O^- Na^+ \xrightarrow[heat]{CH_3OH} (CH_3)_2C=CH_2$



14. (a) State the oxidation state of chromium in

(i) potassium chromate (1 mark)

+6

(ii) potassium dichromate (1 mark)

+6

(b) Acidified potassium dichromate was reacted with potassium iodide

(i) state what was observed (1 mark)

Orange solution turns brown

(ii) Write the half equations and the overall equation for the reaction (4 marks)

$Cr_2O_7^{2-}(aq) + 6I^- + 14H^+(aq) \rightarrow 2Cr^{3+}(aq) + 3I_2(aq) + 7H_2O(l)$

(c) Potassium chromate solution was added to aqueous lead II nitrate (1 marks)

(i) state what was observed

Yellow precipitate

(ii) write the ionic equation for the reaction (1 mark)

$Pb^{2+}(aq) + CrO_4^{2-}(aq) \rightarrow PbCrO_4(aq)$

15. (a) (i) Write an equation for the solubility of silver sulphate in water

$Ag_2SO_4(aq) \rightarrow 2Ag^+(aq) + SO_4^{2-}(aq)$

(ii) Determine the molar concentrations of silver and sulphate ions in a saturated solution of silver sulphate at 25°C. (The Ksp, of silver sulphate is 1.7×10^{-5} $moldm^{-3}$ at 25°C) (3 marks)

let the solubility of silver sulphate be x $moldm^{-3}$

$x(2x)^2 = 1.7 \times 10^{-5}$

$x = 0.016 moldm^{-3}$

$[Ag^+] = 0.016 \times 2 = 0.032 moldm^{-3}$

$[SO_4^{2-}] = 0.016 moldm^{-3}$

(b) State how the solubility of silver sulphate would be affected if the following substances were added.

(i) Sodium sulphate solution (1 mark)

Solubility decreases

(ii) Ammonia solution (1 mark)

Solubility increases

(c) Explain your answer in (b)

(3 marks)

Solubility decrease in sodium sulphate due to common ion effect. The sulphate ion ions in solution suppress ionisation of silver sulphate

Solubility increases in ammonia because ammonia complex and remove silver ions in solution which promotes solubility of silver sulphate to replace silver ions.

16. (a) Define the term 'Buffer solution" (2 marks)

A buffer is a solution that resist change in pH when small amount of acid or base are added.

(b) Calculate the mass of sodium ethanoate that should be added to 1 litre of a 0.2M ethanoic acid solution in order to produce a solution of pH = 3.0 (ka for ethanoic acid = 1.8×10^{-5})

From pH = pKa + Log $\frac{salt}{acid}$

$3 = -\log 1.8 \times 10^{-5} + \text{Log } \frac{salt}{0.2}$

[sodium ethanoate) = 0.0036 moldm^{-3}

Formula mass of sodium ethanoate (CH2COONa) = 82

Concentration of sodium ethanoate in g/dm-3 = 0.0036 x 82 =0.2952g

(c) State what would happen to the pH of the solution in (b), if a small amount of the following were added.

(i) sodium hydroxide solution

pH remain unchanged

(ii) hydrochloric acid

pH remain unchanged

(d) State one biological application of a buffer solution (1 mark)

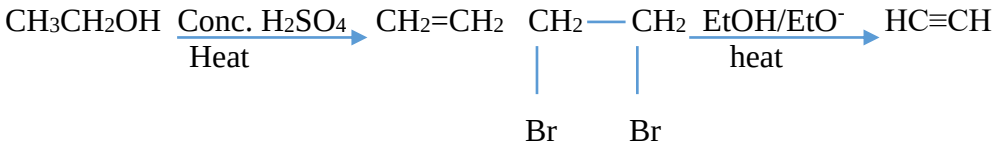
Buffering of blood to enable efficient activity of enzymes

17. (a) Write equation to show how ethanol can be formed from glucose (4 marks)

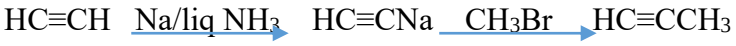
$C_6H_{12}O_6 \xrightarrow{\text{fermentation}} 2CH_3CH_2OH + 2CO_2(g)$

(b) Write equations to show how ethyne can be

(i) prepared from ethanol (4 marks)



(ii) converted to propyne (1 ½ marks)



(c) (i) Name one reagent that can be used to confirm the formation of propyne (1 mark)

ammoniacal silver nitrate

(ii) State what would be observed if propyne was reacted with the reagent you have named in C(i) and write equation for the reaction

White precipitate

(1 ½ marks)