Chem 2005

2005 Chemistry TEE Solutions

Part One: 60 marks

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

Part Two: 70 marks

1. (a) $2C_4H_{10} + 13O_2 \longrightarrow 8CO_2 + 10H_2O$

yellow/orange flame produced, heat released, colourless, odourless gas produced

(b) $Cu^{2+} + Zn \longrightarrow Zn^{2+} + Cu$

Black {brown/salmon pink} precipitate formed on silver solid. Solid dissolves, blue solution fades to colourless.

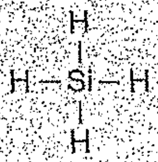
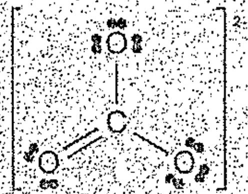
(c) $2H_2O_2 \xrightarrow{MnO_2} 2H_2O + O_2$

Colourless, odourless gas produced, black solid remains.

(d) $2Na + 2H_2O \longrightarrow 2Na^+ + 2OH^- + H_2$

Silver solid dissolves, colourless solution formed, colourless, odourless gas produced. Temperature increase.

2.

Species	Electron Dot Diagram	Shape
SiH_4		Tetrahedral
PCl_3		Pyramidal
CO_3^{2-}		Trigonal planar

3.

Substance	Use	Property
Aluminum	Cookware Wires Window frames	Conducts heat well Conducts electricity well Protective oxide layer
Diamond	Jewelry Cutting tools	High refractive index Hard
Zinc	Anode of battery Galvanized roofs	Easily oxidized Forms protective oxide layer
Stainless Steel	Sinks, tools etc	Corrosion resistant

4. Ions conduct electricity in solution. A high conductivity indicates the presence of ions in solution and a failure of the filter.

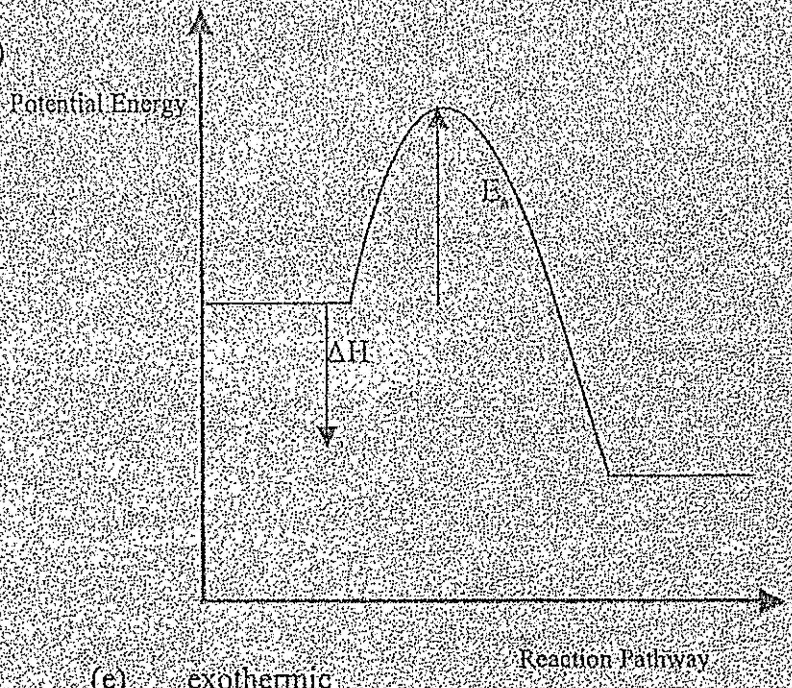
5. The Dispersion forces between the grease and water do not provide enough energy to disrupt the hydrogen bonds between the water particles. Methylated spirits has dispersion forces due to its non polar end and the forces between the Methylated spirits and the grease is enough to overcome the forces of attraction between the grease molecules hence they dissolve.

6. (a) $2Al + Fe_2O_3 \longrightarrow Al_2O_3 + 2Fe$

(b) Finely powdered and thoroughly mixed ensures maximum are of contact ensuring faster reaction rate. This is important because reactants are in solid state.

(c) This reaction has a high activation energy which is provided by the burning Mg.

(d)



(e) exothermic

7. (a) 20 minutes

(b) Increase in the partial pressure of H_2.

(c) Reaction is heated.

(d) No effect

(e) Halving the volume would result in an increase in the amount of methane. Le Chatelier's principle predicts that the side with a fewer number of gas particles will be favoured to counteract the increase in pressure.

8. No, there are no delocalized electrons to conduct electricity.

9. $Cu^{2+} + 2OH^- \longrightarrow Cu(OH)_2$

$Cu(OH)_2 + 4NH_3 \longrightarrow [Cu(NH_3)_4]^{2+} + 2OH^-$

10. Add acidified potassium permanganate solution to each liquid. Solution A changes colour from pink to colourless (brown), there is no change for B.

11. Sodium oxalate can be obtained in a pure form whilst potassium permanganate is difficult to obtain in a pure form. Sodium oxalate is stable in solution whereas potassium permanganate is not.

12. Acetic Acid and Sodium metal:

Silver solid dissolves in colorless liquid colorless odorless gas evolved.

$2CH_3COOH + 2Na \longrightarrow 2CH_3COONa + 2Na$

Acetic acid and ethanol and sulfuric acid

Vinegar smell disappears, fruity odour evolved.

$CH_3COOH + CH_3CH_2OH \longrightarrow CH_3COOCH_2CH_3 + H_2O$

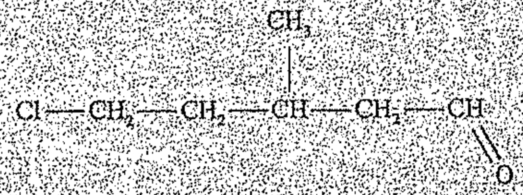
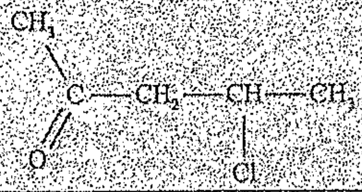
Acetic acid and acidified potassium permanganate

No visible change

No reaction

13.

4


Butanoic acid
2-butanol

$CH_3CH_2CH_2NH_2$
4-chloro-3-methyl-pentanoic acid

Part Three 50 marks

1 (a) $Sn + 2I_2 \Longrightarrow SnI_4$

(b) $n(Sn) = \frac{0.945}{118.7}$

$= 7.96 \times 10^{-3}$ mol

$n(I_2) = \frac{3.67}{253.8}$

$= 1.45 \times 10^{-2}$ mol

1 mole of Sn requires 2 moles of I_2

7.96×10^{-3} mol requires 1.59×10^{-2} mol

$n(I_2)$ required > $n(I_2)$ available

I_2 is LR

(c) $n(SnI_4) = 0.5\, n(I_2)$

$= 7.23 \times 10^{-3}$ mol

$m(SnI_4) = 7.23 \times 10^{-3} (626.3)$

$= 4.53$ g

(d) n(Sn remaining) $= 7.96 \times 10^{-3}$ mol $- 7.23 \times 10^{-3}$ mol

$m(Sn) = 7.30 \times 10^{-4} (118.7)$

$= 0.0867$ g

2. (a) $n(Cu) = \frac{0.544}{63.55}$

$= 8.56 \times 10^{-3}$

$n(e^-) = 2 (8.56 \times 10^{-3})$

$= 1.71 \times 10^{-2}$ mol

(b) $n(C_6H_8O_6) = \frac{1.51}{176.1}$

$= 8.52 \times 10^{-3}$ mol

$n(e^-) = 2\,(C_6H_8O_6)$

2 moles of electrons per mole of $C_6H_8O_6$

(c) $n(e) = \frac{Q}{96500}$

$Q = 1.71 \times 10^{-2}\,(96500)$

$= 1.65 \times 10^{3}$ C

$Q = It$

$I = \frac{1650}{360}$

$= 4.58$ A

(d) $C_6H_8O_6 \longrightarrow C_6H_6O_6 + 2H + 2e^-$

3. $n(H_2O) = 1.834 - 1.648$

$= 0.186$ g

$n(NiS) = \frac{0.238}{90.76}$

$= 2.62 \times 10^{-3}$ mol

$= n(Ni)$

$m(Ni) = 2 \times 2.62 \times 10^{-3} \times 58.7$

$= 0.3078$ g

$n(CO_2) = \frac{0.463}{44.01}$

$= 0.01052$ mol

$n(C_2O_4) = 0.5 \times 0.01052$

$= 0.00526$

$n(C_2O_4)_{tot} = 2 \times 0.00526$

$m(C_2O_4)_{tot}$ = 0.01052 x 88.02

= 0.926 g

m(K) = 1.838 – (.186 + .307 + .926)

= 0.4142 g

	K	Ni	C_2O_4	H_2O
M(g)	0.4142	0.3078	0.926	0.186
n(mol)	0.0105	0.0526	0.01052	0.0103
	2	1	2	2

$K_2Ni(C_2O_4)_2.2H_2O$

4. $Zn + 2H^+ \longrightarrow Zn^{2+} + H_2$

$p(H_2)$ = $P_{total} - P(H_2O)$

= 100.4 – 2.34

= 98.06 kPa

PV = nRT

n = $\frac{98.06 \times 0.916}{8.314 \times 298}$

= 3.625×10^{-2} mol

n(Zn) = 3.625×10^{-2}

m(Zn) = $3.625 \times 10^{-2} \times 65.4$

= 2.37 g

%(Zn) = (2.37/2.79) x 100

$= 84.9\ \%$

5. (a) $V(NaOH) = 35.96\ mL$

$n(OH^-) = 0.106\ (35.96 \times 10^{-3})$

$= 3.81 \times 10^{-3}$

$= n(H^+)$

$[H^+] = 0.381\ molL^{-1}$

(b) $n(OH^-) = 0.106\ (.0104)$

$= 1.10 \times 10^{-3}$

$n(H^+) = 1.10 \times 10^{-3}$ in 50 mL sample

$n(H^+)_{left} = \frac{500 \times 0.0011}{50}$

$= 1.10 \times 10^{-2}\ mol$

$n(H^+)_{initial} = 0.500 \times 1.10 \times 10^{-2}$

$= 0.1905$

$n(H^+)_{used} = 0.1905 - 0.0110$

$= 0.1795\ mol$

$MgO + 2H^+ \longrightarrow Mg^{2+} + H_2O$

$n(MgO) = 0.5 \times n(H^+)_{used}$

$= 0.08975\ mol$

$m(MgO) = 0.08975\ (40.3)$

$= 3.62\ g$

$\%\ (MgO) = \frac{3.62}{3.86} \times \frac{100}{1}$

$= 93.7\ \%$

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Part Four: 20 marks

The temptation in this essay would be for students to just copy from information stored in their calculator on three of the processes. The examiners clearly asked students to compare and contrast three of the processes.

One approach to this essay maybe the following. This is not meant to be a perfect essay but covers the main points as set down by the examiners.

In the Haber Process, nitrogen and hydrogen gas combine to form ammonia in an exothermic reaction:

$$N_2 + 3H_{2(g)} \Leftrightarrow 2NH_{3(g)} + \text{heat}$$

As the NH_3 forms, it also decomposes (reverse reaction) establishing equilibrium. Thus, to favour formation of NH_3, low temperature (favours exothermic forward reaction high pressure [shift to reduce pressure converting 4 moles gaseous reactants to 2 moles gaseous products]) and high concentration of reactants, low concentration of products (frequent removal of NH_3). High temperatures favour economic rate of reaction; thus a compromise temperature (500°C), employing Fe/Fe_2O_3 catalyst, is employed; high pressure and high concentration of reactants also increases rate (as well as yield). Although costly, 350 atmospheres is used.

In the Contact Process the manufacture of SO_3 from SO_2 is also exothermic, and also an equilibrium:

$$2SO_{2(g)} + O_{2(g)} \Leftrightarrow 2SO_3 + \text{heat}$$

In almost identical conditions (3 moles gas reactants to 2 moles gas products), low temperature, high pressure favour high yield, and, like in the Haber process, a catalyst (V_2O_5) allows a satisfactory rate at reduced temperature (450°C) whilst also accommodating yield considerations.

Unlike the Haber Process, a pressure of 1-2 atmospheres is sufficient to enable an economic rate (enhanced by V_2O_5 catalyst) and satisfactory yield. Both these processes use air (N_2 for NH_3, O_2 for SO_3) to produce a compound from elements. Both these reactions are gas phase, redox reactions.

Similarly in the reduction of molten Al_2O_3, electrolysis occurs:

$$Al^{3+}_{(\ell)} + 3e^- \rightarrow Al_{(\ell)}$$

$$C_{(g)} + 2O^{-}_{2(e)} \rightarrow CO_{2(g)} = 4e^{-}$$

These are redox reactions, similar to Haber and Contact Processes. Unlike the first 2 processes, an external energy source (E.M.F.) drives this reaction to completion (not equilibrium). Unlike the first 2, reactions occur in molten phase. Unlike the first 2, an element is produced from a compound. $A1_2O_3$ is used in both the Hall Heroult Process and the Haber Process – but in the former it is consumed as a reactant in the latter not consumed as a provider for the Fe_2O_3/Fe catalyst.

High temperatures are utilised in all processes, but in the Haber and Contact Processes, they are compromisingly high to ensure adequate rate; in the Hall-Heroult Process, they are high to ensure molten state for conductivity-rate is governed by amount of current flowing in electrolysis.