SOLUTIONS AQUINAS 2013 CHEM Stage 3 EXAM

SECTION 1 – Multiple Choice

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

SECTION 2 – Short Answer

* + 1. Valence shell electron pair repulsion theory, is used to predict the shape of molecules based on the repulsion of pairs of electrons.
    2. CF4 four bond pairs surround central atom therefore equal repulsion between pairs of electrons 109 tetrahedral in shape. PH3 has lone pair closer to nucleus greater repulsion pushes bonded pairs closer together forms pyramidal shape.

|  |  |  |
| --- | --- | --- |
| **Pairs of substances** | **Higher boiling substance** | **Intermolecular force responsible for the difference** |
| F2 and Cl2 | Cl2 | Dispersion |
| CH2CH2OH and CH3CH2NH2 | CH2CH2OH | Hydrogen bond |
| CH3(CH2)10OH and CH3OH | CH3(CH2)10OH | dispersion |
| Br2 and ICl | ICl | Dipole-dipole |

* + 1. Metals are bonded with positive metal ions and negative delocalised electrons If hit with hammer, metal ions are able to move (Indent) but still not repel each other due to the free delocalised electrons between them which reduce repulsion Diamond and glass – are made from C and SiO2 respectively in a network lattice which is very strong but when it is hit with hammer the lattice is disrupted which will causes the particles to break apart and shatter
    2. The intermolecular forces of attraction between the water molecules and the grease molecules are weaker than the hydrogen bonds which hold water molecules together. On the other hand the intermolecular forces between the methylated spirit molecules and the grease molecules are stronger than the intermolecular forces between the grease molecules or between the methylated spirit molecules. Dispersion forces between the ethanol and the grease molecules provides enough energy to break the attraction forces between the grease molecules.

|  |  |  |
| --- | --- | --- |
| **Species** | **Electron Dot Structure**  **(showing all valence shell electrons)** | **Shape**  **(sketch or name)** |
| CO32- |  | Triagonal planar (although double bond does have greater repulsion |
| CHI3 |  | tetrahedral |
| Mg(NO3)2 |  | Nitrate ion is triagonal planar but linear with Mg |

310x 1.15\*106 = 3.56\*108g x 24 = 8.544\*109 / 32 = 2.67\*108 O2 moles each day

PV=nRT

101.3 x V = 2.67x108 x 8.315x 293

V = 6430447933 litres of oxygen

Volume of air = x 100/21 = 3.062\*1010 litres of air

1.55\*104 x 680 = n x 8.315 x 293

4326.24 = n in each cylinder

Total volume of O2 produced each hour = 1.1140625\*107/4326.24 = 2575. cylinders of O2

**OR**

310 x 1.5\*106 = 3.565 \*108 O2 p/hr / Mr(32) = 1.14 x 107 mol

PV= nRT V = 1.75 \*106 / 680 = 2572.86 cylinders

NaCl solution: *n*(NaCl) = 0.256 × 0.200 =0.05120 mol = *n*(Na+)

Na2SO4 solution: *n*(Na2SO4) = 0.166 × 0.150 = 0.02490

*n*(Na+) = 2 × 0.02490 = 0.04980 mol

total amount of Na+ = 0.0512 + 0.04980 = 0.101mol

*c*(Na+) = = 0.29 mol L–1

amount of Cl2

*n* = = 0.01417 mol

amount of Fe2+ n(FeSO4) = 0.396 × 0.140 = 0.05544 mol

= *n*(Fe2+)

From the balanced equation

1 mol of Cl2 reacts with 2 mol of Fe2+

so 0.01417 mol of Cl2 will react with 2 × 0.01417 = 0.02834 mol of Fe2+

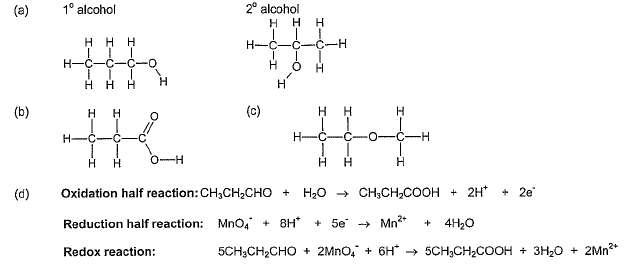
but there is 0.05544 mol of Fe2+ present in the mixture, so Fe2+ is in excess

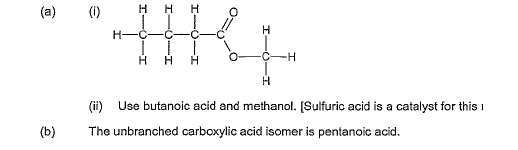
From balanced equation

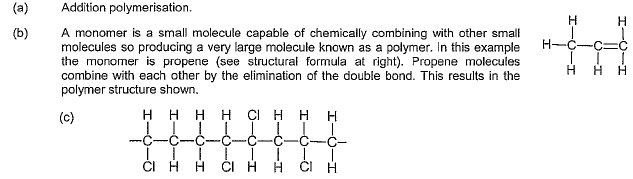
1 mol of Cl2 will form 2 mol of Fe3+

so 0.01417 mol of Cl2 will form 2 × 0.01417 = 0.02834 mol of Fe3+

*c*(Fe3+) = = 0.202 mol







* 1. Decrease in forward rxn due to AgCl ppt forming and reducing conc of Ag+
  2. Decrease in forward rxn more solid dissociates into soln
  3. No change as saturated soln
  4. Exothermic reaction

Labels on both axis

Ea and delta H labelled

Reactants and Products

* 1. PCl3 + Cl2 🡨🡪 PCl5
  2. Reaches equilibrium by Conc of PCl3 and Cl2 decreases as creates PCl5. PCl5 conc increases
  3. Increase in conc of Cl2 by adding more Cl2 to reaction
  4. At t = 17 increase in conc of Cl2 causes reaction to move to right to reduce stress by using up Cl2 in doing so it uses up PCl3 (lowering its conc) and creates more PCl5 (increasing its conc)
  5. Increase in pressure causes increase in the concentration of each of the reactants and products
  6. Works to reduce the stress by reaction mixture moving to right to side with least number of molecules as will reduce the pressure in the system. Reduces conc of Cl2 and PCl3 increases conc of PCl5
  7. Reaction is heated and as reaction produces heat in forward reaction, equilibrium moves to left increasing conc of PCl3 and Cl2 and reduces conc of PCl5
  8. NaHCO3(s) + H+ 🡪 Na+(aq) + CO2(g) + H2O(l)
  9. Ba2+ + SO42- 🡪 BaSO4

**Section 3 – Extended Answer**

**Question 10**

When copper (II) sulphate is dissolved in water a blue coloured solution of Cu2+(aq) ions are formed and when treated with excess concentrated ammonia solution the initial precipitate of copper hydroxide dissolves to give a deep blue solution. When ethanol is added to the solution, deep blue crystals precipitate. When the solution is filtered the crystals smell of ammonia, and an unstable salt with the formula Cu(NH3)xSO4.yH2O has been formed.

(a) When 1.4009g of the unstable salt is heated at 300oC, the salt decomposes and the ammonia is driven off. The ammonia that is produced is captured and found to occupy 539.1mL at 250oC and 104.5 kPa. Calculate the number of moles of ammonia in the 1.4009g sample of the complex salt. [2M]

moles of ammonia – PV=nRT

104.5 x 0.5391 = n x 8.315 x 523.1

n = 56.33595 = 0.0130 moles NH3

4348.745

(b) Calculate the mass of the ammonia in the 1.4009g sample. [2M]

moles x Mr = 0.01295 x 17.034 = 0.221 g

(c) Another 1.4009g sample of the unstable salt is heated at 300oC driving all off the ammonia and water leaving only 0.9055g of copper(II) sulphate behind. Calculate the mass of water in a 1.4009g sample of the unstable salt. [2M]

0.9055+ 0.2205903 = 1.126

1.4009 – 1.1260903 = 0.275g H2O

(d) Calculate the number of moles of water in a 1.4009g sample of the unstable salt. [1M]

0.2748097 / 18.016 = 0.0153 moles H2O

(e) Calculate the number of moles of copper (II) sulphate in the 0.90551g sample of copper sulphate. [1M]

Mr = 159.61

Moles = 0.90551/159.61 = 0.00567 moles Cu(II) SO4

**Question 11**

NH3

N converted to

NaOH

V = 5.90 ml

c = 1.028 mol L-1

HCl

V = 50.0 ml

c = 0.1970 mol L-1

Dried Protein

m = 0.895 g

Unreacted HCl

n(NaOH) = c x V = 1.028 x 0.00590 = 6.065 x 10-3 mol **(1)**

 **(1)**

n(unreacted HCl) = n(NaOH) = 6.065 x 10-3 mol **(1)**

n(HCl before reaction) = c x V = 0.1970 x 0.050 = 9.850 x 10-3 mol **(1)**

n(HCl reacting with NH3) = n(HCl before reaction) - n(unreacted HCl)

= (9.850 x 10-3) – (6.065 x 10-3)

= 3.785 x 10-3 mol **(1)**

 **(1)**

n(NH3) = n(HCl) = 3.785 x 10-3 mol **(1)**

n(N in protein) = n(NH3) = 3.785 x 10-3 mol **(1)**

m(N in protein) = n x M = (3.785 x 10-3) x 14.01 = 0.0530 g **(1)**

**%(N)** = [m(N in protein) / m(protein)] x 100 = [0.0530 / 0.895] x 100 = 5.92%

**(1)**

**Question 12**

Contrary to expectations, the size of an atom as measured by its atomic radius does not simply increase as the number of subatomic particles in the atom increases.

Explain this statement using diagrams

Happens across period

Increase in nuclear charge due to increase in number of protons

No increase in screening effect as still the same energy level

Increase in core charge (number of protons – inner electrons)

Increased repulsion but e- held closer due to increasingly positive nucleus

Radius increases down a group due to increased number of energy levels, screening effect etc… [6M]

Using three examples of your choice, explain the following statement. Use relevant bonding diagrams in your answer.

“There is a continuum from pure covalent bonding, through polar covalent bonding, to ionic bonding”

Bonding is the force of attraction between atoms in a molecule

Electronegativity (EN) is the measure of the power of an atom for the shared pair of electrons in a covalent bond

The greater the EN value the greater the ability to take the electrons

Pure covalent – equal EN value both have equal share of electrons

Polar covalent – one atom has greater attraction for shared electrons as has higher EN, e- spend more time around this atom creating a positive dipole (is asymmetrical molecule)

Ionic – large EN difference greater that 1.7 one atom takes the shared pair of electrons and forms a negative ion other atom is the positive ion. [6M]

**Question 13**

The industrial process of ethanol is an increasingly important one, the equation for this reaction is:

C2H4(g) + H2O(g) ⇌ C2H5OH(g) ∆H = -45 kJ mol-1

A flow chart for the reaction looks like this:

300℃

65 atm

Phosphoric (V) acid coated in SiO2 catalyst

1 volume of ethene

+

0.6 volumes of steam

Unreacted gases recycled

Gases are cooled and ethanol turns to liquid

Ethanol

1. State and explain the ideal conditions for increased rate of the formation of ethanol. [2M]

High temp, high pressure

1. State and explain the ideal conditions for increased yield of ethanol. [2M]

Low temperature, high pressure

1. Explain the compromises made, and the reasons for these, in the actual conditions used in the industrial production of ethanol. [2M]

Intermediate temp and pressure due to safety and cost

1. Catalysts are used in this process. State and explain their function in industrial processes with the aid of an energy profile diagram. [3M]

Provide alternative route with a lower activation energy for the reaction therefore increasing the particles with sufficient activation energy

1. Theoretically what mass of ethanol is produced from 10 000L of ethene at the conditions listed above? [6M]

PV= nRT n x M = 636,545.567g = 637 000 g C2H5OH

1. Theoretically if 350L of ethanol were produced what is the % efficiency of the process [2M] 350/10000 x 100 = 3.50%
2. Using the collision theory explain why it is important to remove the ethanol from the system and add more reactants as well as recycling the unreacted gases[3M]

The concentrations of the solutions decreases during the reaction. [1]

According to the collision theory, reactions occur due to successful collisions between reactant particles. [1M]

As the concentration of particles is initially higher, the frequency of collisions will be greater after the number of ethanol molecules increase the number of successful collisions is lower(1M)

**Question 14**

(a) n(CeO2) = m/M = 2.312/172.1147 = 1.343 x 10-2 moles **(1)**

n(Ce(IV)) = n(CeO2) = 1.343 x 10-2 moles **(1)**

This Ce(IV) comes from the Ce(III) and Ce(IV) in the original mass of sample before oxidation of Ce(III).

Hence, n(Ce(III) + Ce(IV)) in 2.167 g sample = 1.343 x 10-2 moles

m(Ce(III) + Ce(IV)) in 2.167 g sample = n x M = (1.343 x 10-2) x 140.1159

= 1.882 g **(1)**

In 1.528 g sample, n(NO3-) = m/M = 0.5230/62.0049 = 8.435 x 10-3 mol **(1)**

3 mol of NO3- are found in 1 mole of Ce(NO3)3

Therfore n(Ce(NO3)3) = n(NO3-)/3 = (8.435 x 10-3)/ 3 = 2.812 x 10-3 **(1)**

n(Ce(III)) = n(Ce(NO3)3) = 2.812 x 10-3 **(1)**

m(Ce(III)) = n x M = (2.812 x 10-3 ) x 140.1159 = 0.3940 g **(1)**

**%(Ce(III))** = [m(Ce(III))/m(sample)] x 100 = [0.3940/1.528] x 100 = **25.8% (1)**

In 2.167 g of sample, m(Ce(III)) = (25.8/100) x 2.167 = 0.5587 g **(1)**

In 2.167 g of sample, m(Ce(III) + Ce(IV)) = 1.882 g

Therefore m(Ce(IV)) in 2.167 g sample = 1.882 – 0.5587 = 1.323 g **(1)**

**%(Ce(IV))** = [m(Ce(IV))/m(sample)] x 100 = [1.323/2.167] x 100 = **61.1 % (1)**

(b) n(I2) = 2 x n(CeO2) = (2 x 1.343 x 10-2) = 2.687 x 10-2 moles **(1)**

**p(I2)** = (nRT)/V = [(2.687 x 10-2) x 8.31451 x 298] / 0.2554 = **261 kPa** **(1)**

**Question 15**

n(CO2) = PV/RT = (154.2 x 3.72)/(8.3145 x 300) = 0.2300 mol **(1)**

n(Na) = m/M = 4.52 / 22.9897 = 0.1970 mol **(1)**

How many moles of Na is needed to consume all the CO2?

n(Na) = 4 x [n(CO2)/3] = 4 x [0.2300 / 3] = 0.3066. We only have 0.2300. Hence, sodium is the limiting reagent **(1)**.

n(Na2CO3) = 0.5 x n(Na) =0.5 x 0.1970 = 0.0983 mol **(1/2)**

m(Na2CO3) = n x M = 0.0983 x 105.988 = **10.4 g** **(1/2)**

n()used =(3/4) x n(Na) = (3/4) x 0.3066 = 0.147 **(1)**

n()remaining = n()start - n()used = 0.2300 - 0.147 = **0.0825 mol** **(1)**

**Question 16**

%(Mn) = [M(Mn)/M(MnO2)] x 100 = (54.9380/86.9368) x 100 = 63.19 **(1)**

n(Mn) = m/M = (2.50 x 106)/54.9380 = 4.55 x 104 **(1)**

n(MnO2) = n(Mn) = 4.55 x 104 **(1)**

m(MnO2) = n x M = (4.55 x 104) x 86.9368 = 3.96 x 106 g **(1)**

%(MnO2) = [m(MnO2)/m(ore)] x 100

47.2 = [(3.96 x 106)/m(ore)] x 100 **(1)**

**m(ore)** = 8.38 x 106 g = **8.38 tonnes (1)**

**Question 17**

Rate correct [1M]

Yield correct [1M]

Eq correct [1M]

Equation {1M]

Layout [1M]