CHEMISTRY

Unit 2 – Written Examination 2

2009 Trial Examination

SOLUTIONS

SECTION A: Multiple-choice questions (1 mark each)

Question 1

Answer: C

Explanation:

Oxidation is the loss of electrons. Remember OIL RIG. Oxidation is loss and reduction is gain of electrons. Response A does not specify how the electrons are transferred whereas response C details that the electrons are lost from the chemical species.

Question 2

Answer: C

Explanation:

Find the number of moles of $(NH_4)_2SO_4$, then use the number of moles to calculate the concentration. $n = \frac{m}{M} = \frac{45.3}{((14+4)\times 2+32+16\times 4)} = 0.343 \text{ moles}$

$C = \frac{n}{V} = \frac{0.343}{0.085} = 4.04 \text{ M}$

Question 3

Answer: C

Explanation:

The sacrificial anode will only work if a more reactive metal. Saline solution will enhance the rate of corrosion.

Question 4

Answer: B

Explanation:

Determine the balanced equation for the reaction between the acid and the base:

$$HCl(aq) + KOH(aq) \rightarrow KCl(aq) + H_2O(l)$$

Calculate the number of moles of HCl $n = CxV = 0.85x0.50 = 0.425$ moles of HCl
From the equation n(HCl) : n(KOH) = 1:1 therefore 0.425 moles of HCl will require 0.425 moles of KOH.

The mass of KOH required can be calculated from the number of moles of KOH. Note that the 750 ml of deionised water is not required for any calculations.

$n = \frac{m}{M}, m = nxM$. m (KOH) = $0.425x(39+16+1) = 23.8$ g

Question 5

Answer: C

Explanation:

Dilute or concentrated refers to the actual number of moles of acid or base in solution. 0.003 M would be considered dilute. A strong or weak acid is determined by the extent to which the acid donates a proton (H^+). A solution of CH_3COOH is a weak acid and HCl, HF and HNO_3 are all strong acids. The volume of acid used does not determine if the acid is strong or dilute.

Question 6

Answer: B

Explanation:

Using the balanced chemical equation determine the number of moles of reactant and hence the limiting reagent then determine the number of moles of product which can be used to calculate the mass of the product.

	$2NH_3$ +	H_2SO_4 →	$(NH_4)_2SO_4$
Mass (g)	25.0	30.0	
$n = \frac{m}{M}$	$\frac{25.0}{(14+1x3)} = 1.47$	$\frac{30.0}{(1x2+32+16x4)} = 0.306$	
Mole ratio	2	1	1
Limiting reagent		H_2SO_4	
Moles reacting	0.306 * 2	0.306	0.306
Mass of Product			$m = nxM$ $m = 0.306*((14+4)*2+32+16*4)$ $m = 0.306*132$ $m = 40.39 \approx 40.4g$

40.4 g = Answer B

Question 7

Answer: A

Explanation:

Amphiprotic is the ability of a substance to either accept or donate a proton. Each chemical in the list must contain a proton and also be capable of donating a proton.

Question 8

Answer: D

Explanation:

$pH = -\log [H_3O^+]$
$[H_3O^+] = 10^{-pH} = 10^{-0} = 1.0$ M

Question 9

Answer: B

Explanation:

There are 12 principles of Green Chemistry. Renewable and not non-renewable resources should be used. The remaining answers are all valid.

Question 10

Answer: D

Explanation:

All the processes produce carbon dioxide. Respiration always produces carbon dioxide and photosynthesis consumes carbon dioxide. Burning of any fossil fuels such as wood (bushfire) or fuel (unleaded) will produce carbon dioxide. Fizzy drinks contain dissolved carbon dioxide which is released upon opening.

Question 11

Answer: D

Explanation:

All the responses provide correct information regarding the properties of water. However, living systems such as animals and plants mostly use water through the reactions of photosynthesis and respiration.

Question 12

Answer: A

Explanation:

Heat energy = (specific heat capacity) x (mass) x (temperature change)
We know the specific heat capacity and temperature, but need to calculate the mass.
$mass = moles \times molar\ mass = 18 \times 18 = 324\,\text{g}$
Heat energy = $4.2 \times 324 \times (75 - (25)) = 68040\,\text{J} = 68.0\,\text{kJ}$

Question 13

Answer: A

Explanation:

Gas molecules move in random **straight** lines not curved directions. All other responses are valid points of the Kinetic Molecular Theory of Gases.

Question 14

Answer: B

Explanation:

Remember that the temperature of the melting point will equal the temperature of the freezing point. -218.79 + 273.15 = 54.36 K which is B.

Question 15

Answer: D

Explanation:

100 050 Pa = 100.05 kPa and 101.325 kPa = 760 mmHg

$$\frac{100.050}{101.325} \times 760 = 750.43669 \approx 750 \text{ mmHg}$$

Question 16

Answer: A

Explanation:

Remember to convert 27 °C to K by adding 273 to obtain 300 K.

$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$. Insert values using appropriate units.

$$\frac{120kPa \times 8.5 \times 10^6 L}{300K} = \frac{60kPa \times V_2}{150K} \quad V_2 = 8.50 \times 10^6 kPa.$$

Remember that the volume of a gas is proportional to the temperature (in Kelvin) but inversely proportional to the pressure. It should be noted that since these two effects cancel, the volume should remain constant and the answer could be obtained / predicted without a calculation.

Question 17

Answer: C

Explanation:

K is always +1 and O is almost always -2. Uranium ion may exhibit variable oxidation states. However, since K and O are fixed the uranium ion must have an oxidation state of +6.

Question 18

Answer: A

Explanation:

High pressure would increase the solubility of a gas and low temperature favours increased gas solubility. Therefore, the oxygen concentration will increase at low water temperature and high pressure.

Question 19

Answer: D

Explanation:

The carbon atoms in carbon dioxide have already fully reacted with oxygen atoms and therefore will not further combust, hence it is non flammable. Also, the CO_2 can be obtained from heating limestone and is a dense gas which serves to suppress the flames and restrict the flow of oxygen to the burning material.

Question 20

Answer: D

Explanation:

A reducing agent (reductant) causes a species to be reduced. From assigning of oxidation numbers it can be seen that the potassium atoms facilitates the reduction of oxygen from O^0 to O^{2-}

SECTION B: Short-answer questions

Question 1

a.

i. $2Al(s) + 6HNO_3(aq) \rightarrow 2Al(NO_3)_3(aq) + 3H_2(g)$

Note that marks are awarded for the correct states, correct chemical formula and a balanced equation.

3 marks

ii.

	2Al +	**6HNO₃** →	**2Al(NO₃)₃** +	**3H₂**
Mass (g)	54.0			
$n = \frac{m}{M}$	$\frac{54}{27} = 2.00$			
Mole ratio	2			3
Moles gas				$\frac{2}{2} * 3 = 3$
STP 1 mole = 22.4L				3 * 22.4
Volume of H_2				67.2 L

Therefore the volume of hydrogen gas produced is 67.2 L

3 marks

b.

i. $pH = -\log_{10}[H_3O^+] = -\log_{10}[3.0] = -0.48$

Note that negative pH values are possible for $[H_3O^+]$ greater than 1.0 M if the acid is assumed to completely dissociate / ionise.

1 mark

ii. Using the result of 2 moles of Al used from **a part ii**.

$2Al + 6HNO_3 \rightarrow 2Al(NO_3)_3 + 3H_2$

$n = C * V$		$3.0 * 0.15 = 0.45$		
Moles	2	0.450		
Mole ratio	2	6	2	3
Limiting reagent		HNO_3		
Moles gas				0.23
STP 1 mole = 22.4L				0.23 * 22.4
Volume of H_2 gas				5.15 L

The volume of hydrogen gas produced has decreased since the new amount of nitric acid is the limiting reagent in the chemical reaction thus lessening the volume of gas produced. 5.15 L of H_2 is produced compared to the 60.2 L in **a part ii.**

2 marks

c.

The ethanoic acid concentration is extremely dilute and ethanoic acid is a weak acid. These two factors will reduce the overall concentration of $[H_3O^+]$

2 marks

Total 11 marks

Question 2

a.

i. Concentration (Na_2CO_3) = $\frac{n}{V}$

Find moles of Na_2CO_3 using $n = \frac{m}{M}$, $n = \frac{1.456g}{(23*2)+12+(16*3)} = 0.0137 moles$

Concentration $= \frac{0.0137 moles}{0.500 litres} = 0.0275 M$

1 mark

ii. Essential criteria of a primary standard include high purity, fixed chemical formula, stable, high solubility and no efflorescence.

2 marks

b.

i. $Na_2CO_3 + 2HNO_3 \rightarrow 2NaNO_3 + H_2O + CO_2$
Note that states are not required

1 mark

ii. When selecting the values for the average titre only use values that are close together.

Average titre $= \frac{(25.93 + 25.88 + 25.90)}{3} = 25.90$ ml

1 mark

iii. To summarise 25.0 ml of 0.0275 M Na_2CO_3 was titrated / neutralised with 25.90 ml of HNO_3
From the equation the mole ratio of Na_2CO_3 to HNO_3 is 1:2

Moles $HNO_3 = CxV = 0.0275x\frac{25.0}{1000}x2 = 1.38x10^{-3}$ moles HNO_3

Concentration $HNO_3 = \frac{n}{V} = \frac{1.38x10^{-3}}{25.90x10^{-3}} = 0.0531M$

The concentration of HNO_3 = 0.0531M
Note consequential marks may be awarded if incorrect value calculated for **a i**.

3 marks

c.

Remember the diluted nitric acid will have a total volume of 200.0 ml

$C_1V_1 = C_2V_2$

$2.0x40.0 = C_2x200.0$

$C_2 = 0.40M$

The new concentration of nitric acid will be 0.40 M

2 marks

Total 10 marks

Question 3

a.

i. Use the equation E=mcΔT

Note that 100 ml of water is equal to 100 g of water and also the temperature change ΔT is equal to 100 – 22.5 = 77.5 °C

$$E = 100 * 4.18 * 77.5$$
$$E = 32395J$$
$$E = 32.4kJ$$

2 marks

ii. Similar calculation to **i**.

$$E = 100 * 0.13 * 77.5$$
$$E = 1010.1J$$
$$E = 1.01kJ$$

2 marks

iii. The energy required to raise the temperature of the water is significantly higher that the energy required to raise an equal mass of copper by the same temperature. This is because polar molecules contain powerful intermolecular hydrogen bonds which can absorb large quantities of energy restricting the molecules and the substance from temperature increases.

2 marks

iv. Ethanol is not a metal and does not contain any metallic ions and consequently will not have any metallic bonds thus accounting for a specific heat capacity value different from that typically seen for a metal. Ethanol; however, does contain a single O-H bond which is comparable to the O-H bonds in water, and hence its specific value is approximately half of the value for water

2 marks

b.

Moles (CsOH) = $\frac{m}{M}$

$$n = \frac{0.235g}{(132.9 + 16 + 1)} = 0.001568moles$$

$$\text{Concentration} = \frac{0.001568moles}{0.310litres} = 0.00506M$$

0.00506M of CsOH = $[OH^-]$ concentration of 0.00506M

Since Kw = 10^{-14} = $[OH^-]$ x $[H_3O^+]$

$$[H_3O^+] = \frac{10^{-14}}{0.00506} = 1.976x10^{-12}$$

$$pH = -\log[H_3O^+] = -\log[1.97x10^{-12}] = 11.7$$

The pH of the CsOH is 11.7

4 marks

Total 12 marks

Question 4

a.

i. If 12.0 L of carbon dioxide are formed then 6.0 L of ethanol will be consumed since the stoichiometric ratios from the equation are respectively 2:1

1 mark

ii. Use volume of ethanol from previous question (i.e. 6.0 L)

$$PV = nRT$$

$$n = \frac{PV}{RT} = \frac{(95x6)}{(8.31x300)} = 0.229moles$$

$$m = nxM = 0.229x46.0 = 10.517g$$

Mass of ethanol combusted = 10.5 g

2 marks

iii. Use volume of ethanol from previous question (i.e. 6.0 L)

$$PV = nRT$$

$$n = \frac{PV}{RT} = \frac{(95x12)}{(8.31x300)} = 0.457moles$$

$$m = nxM = 0.457x44.0 = 20.120g$$

Mass of carbon dioxide produced = 20.1 g

2 marks

b.

20.1 g less 90 %

$20.1 - (20.1x0.9) = 2.0$ g of CO_2 emitted

1 mark

c.

5 °C = 278 K

5 % of 5,000 L = 250 L

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

$$\frac{101.325x5000}{298} = \frac{P_2x250}{278}$$

$$P_2 = 1890\ \text{kPa}$$

The container would need to withstand a minimum pressure of 1890 kPa

2 marks

Total 8 marks

Question 5

a.

i. The Cu^{2+} ions in the $Cu(NO_3)_2$ act as the oxidant.

1 mark

ii. The reducing agent is the Mg metal.

1 mark

b.

i. $Mg(s) \rightarrow Mg^{2+}(aq) + 2e^-$

1 mark

ii. $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$

1 mark

c.

i. Iron in metallic iron is 0
Iron in iron(III) chloride is +3

1 mark

ii. Oxygen in phosphoric acid is -2
Oxygen in ozone is 0

1 mark

d.

i. A galvanised iron nail is covered with zinc metal which acts as a physical barrier against corrosion restricting the action of oxygen and water on the iron nail. The zinc is also more reactive than iron and it will corrode before iron.

1 mark

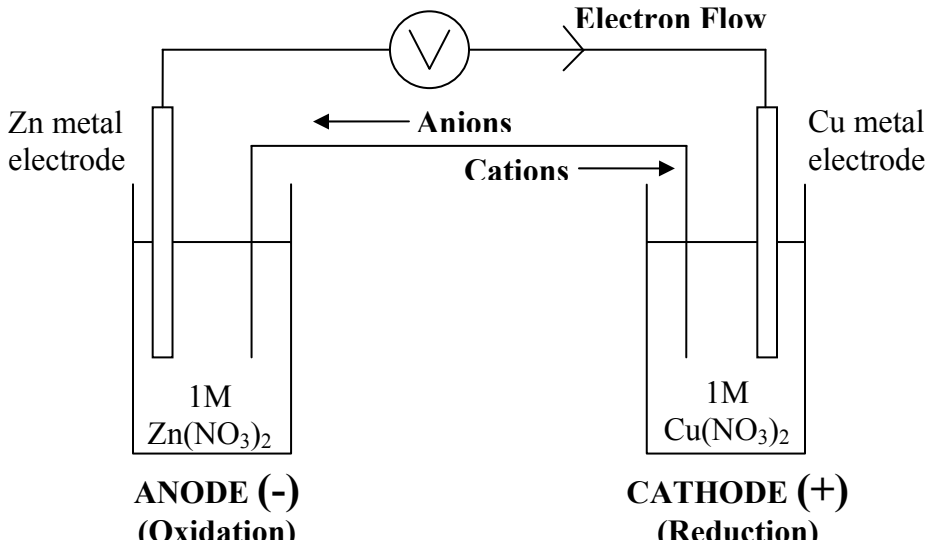
ii. Tin metal is less reactive than iron metal. The iron metal would corrode in preference to the tin metal. This rate of corrosion has been increased.

2 mark

Total 9 marks

Question 6

a.



1 mark

b.

i. The electrons would flow <u>from</u> the copper electrode instead of <u>towards</u> the copper electrode. This would be observed by the change in sign of the voltmeter reading.

1 mark

ii. The mass of the copper electrode would start to decrease as since electrons are flow from this electrode this will be the oxidation site. Hence the copper electrode is being oxidised to produce copper ions and electrons.

1 mark

iii. The colour of the blue $Cu(NO_3)_2$ solution will begin to intensify as the blue colour of the solution is due to the presence of Cu^{2+} ions which are continually being produced.

1 mark

iv. The polarity of the electrode will change from positive to negative as this is now the site of oxidation and not reduction.

1 mark

Total 10 marks