CHEMISTRY
Unit 4 – Written examination 2

2010 Trial Examination

SOLUTIONS

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

Question 1

Answer: C

Explanation:
Gas particles have a range of speeds. The distribution curves highlight the range of velocities of the molecules. If the velocities vary, the kinetic energies will also vary.

Question 2

Answer: D

Explanation:
A higher percentage of molecules will react at 2000°C. Some molecules at each temperature have energy greater than the activation energy but there are more molecules at 2000°C that have energy above the activation energy. Note: 2000°C is not twice the temperature of 1000°C.

Question 3

Answer: A

Explanation:
Phenolphthalein is a weaker acid than methyl red. Therefore it forms less H_3O^+ ions. Therefore its pH is higher than that of methyl red. The data book gives K_a values.

Question 4

Answer: A

Explanation:
The value of K of 4.6×10^{-4} is very low. This means the amount of product is much less than the amount of reactant. This means the amount of NO will be far lower than the amounts of nitrogen and oxygen. Be careful applying stoichiometry to reversible equations.

Question 5

Answer: B

Explanation:
Graph A does not climb as much as graph B hence it has a lower activation energy. It does however, have a bigger difference between its final and initial positions hence its ΔH is greater.

Question 6

Answer: A

Explanation:
All activation energies have a final value greater than the original.
Answer B depends upon whether the reaction is exo or endothermic.
Alternative C only applies at 25°C and electrons travel the opposite direction to D.

Question 7

Answer: C

Explanation:
$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$
From the equation, the reactants must decrease the same amount, while hydrogen increases at three times this rate. Alternative C matches this – the reactants both drop by 0.1 while hydrogen increases by three times this.

Question 8

Answer: D

Explanation:

$K_a = \frac{[H_3O^+][A^-]}{[HA]}$ (where the weak acid is represented as HA)

Assume that $[H_3O^+] = [A^-]$

$K_a = \frac{[0.00114][0.00114]}{[0.1]} = 1.3 \times 10^{-5}$

This matches propanoic acid (from Data Booklet)

Question 9

Answer: C

Explanation:
2% of 0.1 M = 0.002 M
pH = -log[0.002] = 2.7

Question 10

Answer: A

Explanation:
If temperature increases, the back reaction is favoured. This means K drops and there are more reactants and less products. This matches A.

Question 11

Answer: C

Explanation:
Any metal extracted from aqueous solution must be placed above the water half equation at -0.8 on the electrochemical series. The only correct response is C.

Question 12

Answer: B

Explanation:
0.1 g of methanol is $\frac{0.1}{32} = 0.00313mol$
Energy = 0.00313 x 725 = 2.270J *(using data book)*
CF=$\frac{energy}{\Delta T} = \frac{2.270}{10} = 0.2270$

Question 13

Answer: A

Explanation:
From the electrochemical series, chlorine gas will react with magnesium metal. The magnesium is oxidised, making it the anode. The anode will be negative. The magnesium electrode loses mass as the magnesium atoms become magnesium ions. Alternative A matches the above discussion.

Question 14

Answer: A

Explanation:
Half equations are:
$Li(s) \rightarrow Li^+(l) + e^-$
$I_2(l) + 2e^- \rightarrow 2I^-(l)$
This leads to the overall equation shown in option A.

Question 15

Answer: C

Explanation:
n(Mg)=$\frac{0.1}{24.3} = 0.0041mol$

Energy for 1 mole = $\frac{540}{0.0041} = 132kJ$

Equation is: $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$ $\Delta H = 2 \times 132 = -264kJ$

Question 16

Answer: A

Explanation:
In this cell, $Ag^{+}(aq)$ reacts with Ni(s);
$2Ag^{+}(aq) + 2e^{-} \rightarrow 2Ag(s)$
$Ni(s) \rightarrow Ni^{2+}(aq) + 2e^{-}$
The products are Ag(s) and $Ni^{2+}(aq)$, which is green.

Question 17

Answer: B

Explanation:
$2Ag^{+}(aq) + 2e^{-} \rightarrow 2Ag(s)$
$Ni(s) \rightarrow Ni^{2+}(aq) + 2e^{-}$
The reaction of silver ions is reduction. Reduction occurs at the cathode and the cathode is positive. This matches B.

Question 18

Answer: C

Explanation:
Q=It = 2.1 x 5 x 60 = 630*coulomb*

$n(e) = \dfrac{630}{96500} = 6.52 \times 10^{-3}$

$n(Sn) = \dfrac{0.388}{118.7} = 3.26 \times 10^{-3}$

ratio of n(Sn):n(e) = 1:2 therefore Sn^{2+}

Question 19

Answer: B

Explanation:
$n(Cl_2) = n(Sn)$ as $2Cl^{-}(l) \rightarrow Cl_2(g) + 2e^{-}$

$V = n \times 22.4 = 3.26 \times 10^{-3} \times 22.4 = 0.0732\ L$

Question 20

Answer: C

Explanation:
In conventional nuclear reactors, uranium atoms are split to smaller atoms. This releases energy and neutrons, forming a chain reaction.

SECTION B: Short answer questions

*An * indicates the allocation of 1 mark*

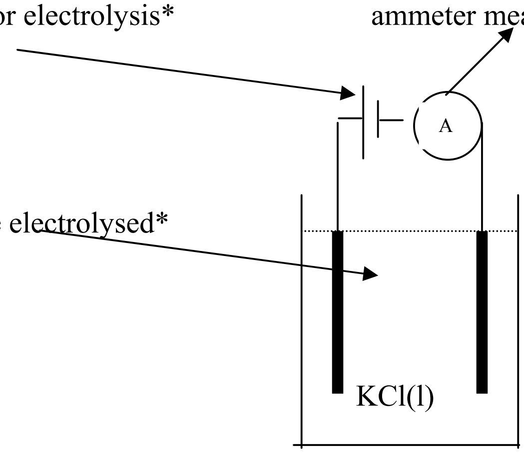
Question 1

Task 1

a. **i**. power supply required for electrolysis*

ammeter measure current*

molten solution of KCl to be electrolysed*



Bunsen drawn here*

ii. $2K^+(l) + 2Cl^-(l) \rightarrow 2K(l) + Cl_2(g)$**

iii. Some combination of Q = It that gives 96500 coulomb as $K^+ + e^- \rightarrow K$

current = 1 amp time = 96500 sec *

4 + 2 + 1 = 7 marks

Task 2

b. **i.** Remove the Bunsen* and swap the molten solution for an aqueous solution of KCl*

ii. $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$* (can be obtained from Data Booklet)

iii. reduction at the cathode, cathode is negative*

2 + 1 + 1 = 4 marks
Total 11 marks

Question 2

a.	**Equation**	**ΔH**
Ethanol	$CH_3CH_2OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$*	-1364 kJ mol^{-1} *
Methanol	$2CH_3OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 4H_2O(g)$*	-1450 kJ mol^{-1} *

4 marks

b. **i**. E = n x ΔH

$$= * \frac{0.2}{46} \times 1364 = 5930J *$$

ii. E = n x ΔH

$$= * \frac{0.4}{32} \times 725 = 9063J *$$

4 marks

c. **i**. Assume 30 mL = 30g

60% of heat transferred = 5930 x 0.60

= 3558 J

$$E = 4.18 \times 30 \times \Delta T = 3558$$

$$\Delta T = 28.4$$

Final temp = 46 °C **

ii. Assume 50 mL = 50g

60% of heat transferred = 9063 x 0.60

= 5436 J

$$E = 4.18 \times 50 \times \Delta T = 5436$$

$$\Delta T = 26$$

Final temp = 48 °C **

4 marks

Total 12 marks

Question 3

a. **i**. This will not be true* because not all of the carbon monoxide will react. The amount of hydrogen reacting will be double that of carbon monoxide but it will not be the whole 10 mol reacting*

ii. This will not be true*. The stoichiometry of the equation shows that the number of mole of hydrogen must be twice that of carbon monoxide*

iii. This is true*. The system will move to decrease the pressure by moving in the forward direction. This is exothermic*

1 + 1 + 2 = 4 marks

b. Graph B shows K dropping as temperature increases. (exothermic reaction)*

c. $K = \frac{[CH_3OH]}{[CO][H_2]^2}$ *

As methanol is the only reactant at the start, twice as much hydrogen is formed as carbon monoxide.

Let [CO] = X, then [H_2]=2X *

$$1 = \frac{0.1}{X \times (2X)^2}$$

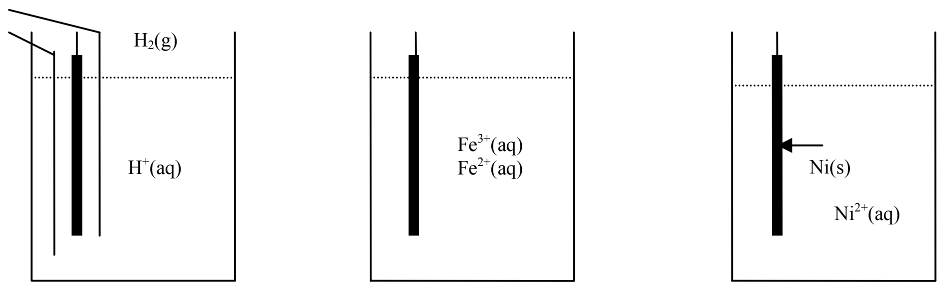
$$4X^3 = \frac{0.1}{1} = 0.1 \quad *$$

$$X = \sqrt[3]{0.025} = 0.29M$$

3 marks

Total 8 marks

Question 4



A **B** **C**

a. **i**. Beaker A: $2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$

ii. Beaker B: $Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$ See diagram above***

iii. Beaker C: $Ni^{2+}(aq) + 2e^- \rightleftharpoons Ni(s)$

iv. $Fe^{3+}(aq)$ * (See Data Booklet)

v. Beakers B and C* (See Data Booklet)

1 + 1 + 1 + 1 + 1 = 5 marks

b.

In this cell, the

i. positive electrode will be $Fe^{3+}(aq)$ half cell electrode*

ii. $Fe^{3+}(aq)$ *

iii. electrons will flow from beaker C to beaker B*

1 + 1 + 1 = 3 marks

Total 8 marks

Question 5

	Polarity	
$CoO_2 + Li^+ + e^- \rightarrow LiCoO_2$	+	cathode*
$LiC_6 \rightarrow C_6 + Li^+ + e^-$	-	anode *

(phases are not shown as organic solvents are used)

a. **i**. & **ii**. see above

iii. $CoO_2 + LiC_6 \rightarrow LiCoO_2 + C_6$ *

iv. Before = +4 After = +3 *

1 + 1 + 1 + 1 = 4 marks

b.

$E = VIt = 4.6 \times 1.1 \times 5 \times 60 = 1518 Joules *$

1 mark

c. **i**. $LiCoO_2 + C_6 \rightarrow CoO_2 + LiC_6$ *

ii. $LiCoO_2 \rightarrow CoO_2 + Li^+ + e^-$ Anode * (same as during discharge)

1 + 1 = 2 marks

Total 7 marks

Question 6

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

1 mark

b. **i**. pH will increase toward 7. *

ii. It will only get close to 7 if the $CaCO_3$ is in excess*. Given that CO_2 is slightly soluble to form a weak acid, the pH will not reach 7.*

1 + 2 = 3 marks

c. The acid in Beaker B might be about twice the concentration of the acid in flask A. This is assuming the $CaCO_3$ is in excess in both beakers.*

1 mark

d. The $CaCO_3$ in flask A might have been ground into very fine particles, hence the reaction rate is faster. The concentration of the acid might however have been weaker, hence the mass loss is less. Alternatively, the temperature in Beaker A might have been higher and the concentration of the acid weaker. A catalyst is added to the solution.

2 marks

Total 7 marks

Question 7

a. **i**. Choose from NH_3 C_2H_4 HNO_3 H_2SO_4 *

ii. NH_3 H = +1, N = -3 C_2H_4 H= +1, C = -2

HNO_3 H= +1, N = +5, O = -2 H_2SO_4 H= +1, S = +6, O = -2 **

1 + 2 = 3 marks

b. **i**. Several possibilities: $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$

$C_2H_6(g) \rightleftharpoons C_2H_4(g) + H_2(g)$

$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(l)$ *

ii. Answers should refer to control of temperature or adjustment of pressure to push reaction forward or excess of cheaper reactant. Most reactions are exothermic, so high temperature does not help the yield.*

1 + 2 = 3 marks

c. Handling or disposal of toxic or flammable materials. Polluting gases emitted. High temperatures and pressures are dangerous environments.*

1 mark

d. **i**. & **ii.** Air or methane for ammonia. Air is economical, methane is from natural gas.
Sulfur dioxide for sulfuric acid. Mining industry produces waste sulphur dioxide, which can be used as the starting material for the production of sulphuric acid.
Ammonia or air for nitric acid. Ammonia from Haber process.
Petroleum or ethane for ethene.* Natural gas from off Western Australian coast.

1 + 2 = 3 marks
Total 10 marks