CHEMISTRY

Unit 4 – Written examination 2

2012 Trial Examination

SOLUTIONS

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

Question 1

Answer: B

Explanation:

If the manufacturer chooses high temperatures, the reaction must be endothermic. This favours a high yield. There are more molecules of products than reactants, therefore a low pressure is used.

Question 2

Answer: C

Explanation:

If oxygen drops by 1000, the methane will drop by 6000. Total drop is 7000. From the stoichiometry, the number of products formed is 2000 + 1000 + 2000 = 14000. The net increase is therefore 7000.

Question 3

Answer: D

Explanation:

The pH of a sample of pure water is found to be 6.8. This means that the temperature must be other than 25 C. In pure water, H_3O^+ and OH^- must be equal. This makes D the correct answer.

Question 4

Answer: A

Explanation:

The boric acid is such a weak acid it will never be 1.1 pH.
The 2.0 M HCl will be a lower pH than 1.1
The 0.01 M HCl will be 2
The sulfuric acid could be 1.1 as it is diprotic but the second stage of ionisation is a weak acid.

Question 5

Answer: B

Explanation:

$$2HI(g) \rightleftharpoons H_2(g) + I_2(g)$$

0.034	0	0	start
	0.008	0.008	eq

change of 0.008 => HI changes by 0.016
0.034 – 0.016 = 0.018

$K = 0.008 \times 0.008/0.018 = 0.0036$

Question 6

Answer: C

Explanation:

The yield is decreasing as the temperature increases, this makes it exothermic. The use of high pressure is improving the yield so there must be less product molecules than reactant ones.

Question 7

Answer: C

Explanation:

Note that the question asks about rate and not yield. These are very different questions. Increase temperature leads to more collisions, so does increased pressure. A catalyst speeds up a reaction

Question 8

Answer: A

Explanation:

You don't know the concentrations of the acids but you do know that beaker B is the strongest acid, then beaker A and then beaker C. The pH tells you this. Option A is the only one that has Ka values from the data book matching this order.

Question 9

Answer: D

Explanation:

1% of 0.1 is 0.001. If the $[H_3O^+]$ is 0.001 then the pH is 3

Question 10

Answer: B

Explanation:

n(butane) = 1/58 = 0.01724
energy = 0.01724 x 2874 from data book = 49.55 kJ
n(propane) = 49.55/2217 = 0.02234 mol
mass = .002234 x 44 = 0.98 g

Question 11

Answer: D

Explanation:

$$\mathbf{2S(g) + 3O_2(g) \rightarrow 2SO_3(g)}$$

To make the equation above, the other two equations need to be in the order shown

$$S(g) + O_2(g) \rightarrow SO_2(g) \quad \Delta H = -297 \text{ kJ mol}^{-1}$$
$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g) \quad \Delta H = -198 \text{ kJ mol}^{-1}$$

This changes the sign of the second equation

The first equation also needs to be doubled
$2S(g) + 2O_2(g) \rightarrow 2SO_2(g)$ $\Delta H = -594$ kJ mol^{-1}
Total energy change is $-594 + -198 = -792$

Question 12

Answer: A

Explanation:

The same amount of energy goes into both beakers. The ratio of masses is 12:30 which is 1:2.5. The second beaker will increase in temperature by less in the ratio of 1:2.5.
15/2.5 = 6

Question 13

Answer: B

Explanation:

There are some generalisations but galvanic cells are highly efficient while photovoltaic are the least. Nuclear fission is more efficient than brown coal

Question 14

Answer: B

Explanation:

The two half equations for this cell are
$CH_4(g) + 2H_2O(g) \rightarrow CO_2(g) + 8H^+(aq) + 8e^-$ *oxidation anode*
$O_2(g) + 4H^+(aq) + 4e \rightarrow 2H_2O(g)$

Question 15

Answer: A

Explanation:

The half equations are
$2H^+(aq) + 2e \rightarrow H_2(g)$
$Al^{3+}(aq) + 3e \rightarrow Al(s)$

This means the hydrogen ions and the aluminium will react.
$2Al(s) + 6H^+(aq) \rightarrow 2Al^{3+}(aq) + 3H_2(g)$

As the aluminium is releasing 3 electrons, they will flow to the hydrogen, making A correct. Aluminium is the negative electrode and the concentration of aluminium ions is increasing.

Question 16

Answer: D

Explanation:

Answer shown in the previous question as
$2Al(s) + 6H^+(aq) \rightarrow 2Al^{3+}(aq) + 3H_2(g)$

Question 17

Answer: A

Explanation:

The overall equation is formed from the top reaction being added to the lower equation after the lower equation is reversed. This leads to equation A. The water and OH^- cancel out.

$2MnO_2(aq) + Zn(s) \rightarrow Mn_2O_3(s) + ZnO(s)$

Question 18

Answer: A

Explanation:

When this cell is discharging, the pH will not change. Neither half reaction contains acid. Both contain alkali but the rate the alkali is used in one cell is exactly matched by the rate it is produced in the other cell – no net change.

Question 19

Answer: C

Explanation:

$CuBr_2$ would produce equal quantities of both materials as the half equations both have 2 electrons.
Concentrated NaCl will produce equal quantities of hydrogen and chlorine
$MgCl_2$ will produce equal quantities of both magnesium and chlorine as both half equations contain 2 electrons.
0.1 M NaCl will produce twice as much hydrogen at the negative electrode than oxygen at the positive electrode. It is the hydrogen and oxygen gases that form

Question 20

Answer: A

Explanation:

Copper is deposited at the cathode and not the anode. Therefore the answer is 0

SECTION B: Short answer questions

*An * indicates the allocation of 1 mark*

Question 1

a. **i**. $HCN(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + CN^-(aq)$ *

ii.

$$K_a = \frac{[H_3O^+][CN^-]}{[HCN]} = 6.3 \times 10^{-10} \ *$$

Let $[H_3O^+] = x$

$$x^2 = 6.3 \times 10^{-10} \times 0.01$$
$$x^2 = 6.3 \times 10^{-12}$$
$$x = 2.51 \times 10^{-6} \ *$$
$$pH = -\log(2.51 \times 10^{-6}) = 5.6*$$

iii. Several possible reasons – temperature not 25 ^{0}C, purity in question, pH is difficult to measure accurately*

1 + 3 + 1 = 5 marks

b. **i**. The solution with the highest pH will be the (HCN) HCl *

ii. The solution with the highest $[H_3O^+]$ will be the HCN (HCl) *

iii. Which solution would require the largest volume of 0.01 M NaOH to neutralize the acid? (HCN) HCl*

1 + 1 + 1 = 3 marks

Total 8 marks

Question 2

a. **i**. $Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$ *

ii. Fe^{2+} *

iii. Platinum electrode, beaker,* 1.0 M solution of $Fe(NO_3)_3$ and a 1.0 M solution of $Fe(NO_3)_2$ or another solution that is soluble. *

1 + 1 + 2 = 4 marks

b. Fe^{2+} is the negative electrode and Ag the positive *
electrons flow from the platinum in the iron solutions to silver*

$Ag^+(aq) + e^- \rightarrow Ag(s)$ $Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^-$ *

Overall equation: $Ag^+(aq) + Fe^{2+}(aq) \rightarrow Ag(s) + Fe^{3+}(aq)$ *

4 marks
Total 8 marks

Question 3

a. What is the molecular formula of the oxalic acid? $C_2H_2O_4$ *

1 mark

b. When the oxalic acid reacts, it is oxidised to carbon dioxide.

i. Write a balanced half equation for the oxidation of the oxalic acid.

$C_2H_2O_4 \rightarrow 2CO_2(g) + 2H^+(aq) + 2e$ *

ii. reaction above is oxidation, therefore it will be the negative electrode *

1 + 1 = 2 marks

c. **i**. Beaker C, B then A * (the surface area of C is the largest of the three)

ii. Beaker A, B then C *

iii. Slicing the rhubarb horizontally as in C leads to a greater surface area than in B. The greater the surface area, the faster the reaction rate*

1 + 1 + 1 = 3 marks
Total 6 marks

Question 4

a. **i**. The use of sugar cane is more sustainable because further crops can be grown after harvesting*

ii. Sugar cane can lead to a useful food product. Arable land is tied up in fuel production*

1 + 1 = 2 marks

b. **i**. $C_2H_5OH(l) + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$ *

ii. m(ethanol) = d x V = 0.78 x 10000 = 7800 g *

n(ethanol) = m/M = 7800/46 = 170 mol *

E = 170 x 1364 (from data book) = 2.31×10^5 kJ*

1 + 3 = 4 marks

c. anode: $C_2H_5OH(l) + 3H_2O(l) \rightarrow 2CO_2(g) + 12H^+(aq) + 12e$ *

cathode: $O_2(g) + 4H^+(aq) + 4e \rightarrow 2H_2O(l)$ *

2 marks

d. chem potential → thermal → mechanical → kinetic *

1 mark
Total 9 marks

Question 5
Answers for ammonia

a. **i**. $N_2(g) + 3H_2(g) \Leftrightarrow 2NH_3(g)$ *

ii. Exothermic, so the yield will drop as temperature rises *

iii. Increased pressure will favour the forward reaction as it has less particles *

iv. A catalyst is used to lower the activation energy or unused reactants are recycled or some of the ammonia is removed *

1 + 1 + 1 + 1 = 4 marks

b. $CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$ *

1 mark

c. The heat produced in the exothermic production of ammonia is used to heat up the incoming gases*

Answers for sulfuric acid

a. **i**. $2SO_2(g) + O_2(g) \Leftrightarrow 2SO_3(g)$ *

ii. Exothermic, so the yield will drop as temperature rises *

iii. Increased pressure will favour the forward reaction as it has less particles *

iv. A catalyst is used to lower the activation energy or unused reactants are recycled or excess air is used *

1 + 1 + 1 + 1 = 4 marks

b. $S(s) + O_2(g) \rightarrow SO_2(g)$ *

1 mark

c. The heat produced in the exothermic production of sulfuric acid is used to heat up the incoming gases*

1 mark

Answers for nitric acid

a. **i**. $4NH_3(g) + 5O_2(g) \Leftrightarrow 4NO(g) + 6H_2O(g)$*

ii. Exothermic, so the yield will drop as temperature rises *

iii. Increased pressure will favour the reverse reaction as it has less particles *

iv. A catalyst is used to lower the activation energy or the products are cooled rapidly to prevent decomposition or fast passes are made over the catalyst or the ratio of nitrogen to hydrogen is monitored very closely *

1 + 1 + 1 + 1 = 4 marks

b. $N_2(g) + 3H_2(g) \Leftrightarrow 2NH_3$*

1 mark

c. The heat produced in the exothermic production of nitric acid is used to heat up the incoming gases*

Answers for ethene

a. **i**. $C_2H_6(g) \Leftrightarrow C_2H_4(g) + H_2(g)$ * several possible reactions

ii. Endothermic, so the yield will increase as temperature rises *

iii. Increased pressure will favour the back reaction as it has less particles *

iv. A catalyst is used to lower the activation energy or unused reactants are recycled *

1 + 1 + 1 + 1 = 4 marks

b. * C_2H_6 ethane can be formed from fractional distillation or from cracking i.e.
$C_4H_{10} \rightarrow C_2H_4 + C_2H_6$

1 mark

c. The use of a catalyst allows the reaction to proceed at lower temperatures, hence saving energy or significant use of heat exchangers*

Total 6 marks

Question 6

$$CCl_4(g) + 2HF(g) \Leftrightarrow CCl_2F_2(g) + 2HCl(g)$$

a. **i**. That the reaction is endothermic – higher yield gained by higher temperature *

ii. The yield might be satisfactory at 250 ^{0}C, higher temperatures cost more money*,

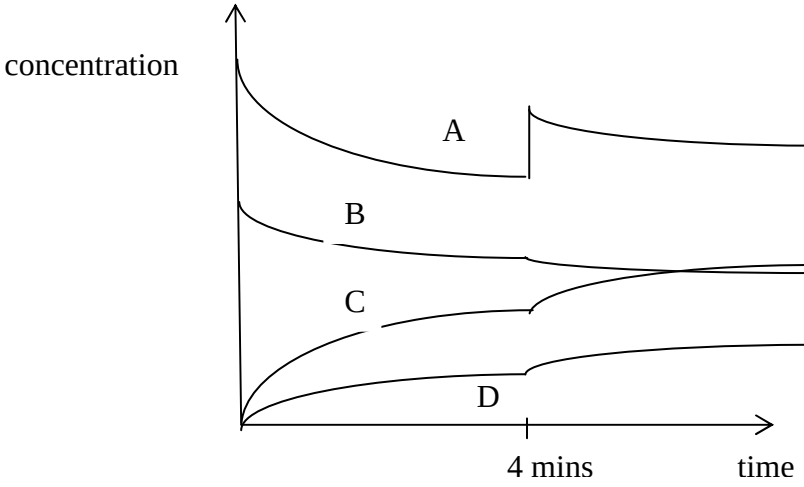
high temperatures can be dangerous.

1 + 2 = 3 marks

b. There is an equal number of mole on both sides of the equation. Changing the pressure will not favour either side of the reaction.*

1 mark

c.



i. Identify which graph represents each substance.

A HF (*gradient tells you this*) B CCl_4

C HCl D CCl_2F_2

ii. Increase in concentration of the HF *

iii. see graph

iv. It will be unchanged. Temperature is the only variable that leads to a temperature change *

2 + 1 + 2 + 1 = 6 marks

Question 7

a. **i**. Cu^{2+}, H_2O, SO_4^{2-} *

ii. $O_2(g) + 4H^+(aq) + 4e \rightarrow 2\underline{H_2O}(l)$ *
$\underline{Cu^{2+}}(aq) + 2e \rightarrow Cu(s)$ *
$\underline{2H_2O}(l) + 2e \rightarrow H_2(g) + 2OH^-(aq)$ *

iii. $2Cu^{2+}(aq) + H_2O(l) \rightarrow O_2(g) + 4H^+(aq) + 2Cu(s)$ *

1 + 3 + 1 = 5 marks

b. Q= It = 0.23 x 6 x 60 = 82.8 C *

$n_e = \frac{Q}{96500} = \frac{82.8}{96500} = 8.6 \times 10^{-4}$ *

$nCu = ½ n_e = 4.3 \times 10^{-4}$

mass = n x M = 4.3×10^{-4} x 63.5 = 0.028 g *

3 marks

c. $nO_2 = ¼ n = ¼ \times 8.6 \times 10^{-4} = 2.15 \times 10^{-4}$ *

$V = n \times 24.5 = 2.15 \times 10^{-4} \times 24.5 = 5.3 \times 10^{-3}$ L *

2 marks

d. nCu^{2+} (start) = c x V = 0.4 x 0.1 = 0.04 mol
$n\,Cu^{2+}$ (finish) = n start – n plated out = $0.04 - 4.3 \times 10^{-4}$

= 0.0396 mol *

c = n/V = 0.0396/0.4 = 0.099 M * 2 marks

Total 12 marks

Question 8

a. The pH of pure water is temperature dependent*. If the temperature warms up significantly during the morning, the pH of the pure water will change. The ionisation of water is an endothermic reaction, so the value of K_w should increase with temperature causing the pH to drop *

2 marks

b. The value of 4.18 does not hold for oil. It is the specific heat capacity of water. This value is significantly higher than that of water*
The number of significant figures used is too many. It should be three at the most*

2 marks

c.

i. The two half equations are further apart than any other combination on the electrochemical series. The potential voltage produced could be very high*

ii. This cell will be too dangerous*. The reaction between lithium and fluorine is too violent. The fluorine is difficult to handle anyway, being a reactive and toxic gas.

1 + 1 = 2 marks
Total 6 marks