CHEMISTRY

Units 3 & 4 – Written examination

*(*TSSM's 2012 trial exam updated for the current study design*)*

SOLUTIONS

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

Question 1

Answer: D

Explanation:

	C	H
Mass	0.480 g	0.100
Mol	0.480/12.0 = 0.0400 mol	0.100/1.0 = 0.100
Ratio	0.0400/0.0400 = 1	0.100/0.0400 = 2.5
	2	5

Empirical formula = C_2H_5

n (compound) = V/V_m = 0.0336/24.5 = 0.00137 mol
M (compound) = m/n = 0.079/0.00137 = 58 g/mol
Molecular formula = C_4H_{10}

Question 2

Answer: A

Explanation:

E = c x m x ΔT
ΔT = E/cm = 1950/ (130 x 0.500) = 30 °C
Therefore the final temperature = 15 + 30 = 45 °C

Question 3

Answer: D

Explanation:

I_2 acts as an oxidant. Ag^+ are a stronger oxidant. The reactions between Fe^{2+} and Br^- will be non-spontaneous. Option D (Sn^{2+}) is the only spontaneous reaction.

Question 4

Answer: C

Explanation:

The reaction releases energy so is therefore exothermic. Exothermic reactions have a change in enthalpy which is less than zero. The reverse reaction is endothermic and the activation energy will be greater than the forward reaction.

Question 5

Answer: B

Explanation:

The two half equations occurring are:
Oxidation: $2H_2O\ (l) \rightarrow O_2\ (g) + 4H^+\ (aq) + 4e^-$
Reduction: $Ag^+\ (aq) + e^- \rightarrow Ag\ (s)$

Therefore Option B is correct as the amount of aqueous silver ions will decrease and the pH will decrease as H^+ ions are being produced.

Question 6

Answer: B

Explanation:

That it can be titrated suggests it is an acid or base, making it B, C or D, eliminating A.
The infrared matches a carboxylic acid with the C = O and O –H absorptions, eliminating C.
The presence of two singlets makes it ethanoic acid, propanoic acid would have more peaks and it would have splitting. (The NMR of ethanoic acid is shown in Q. 10)

Question 7

Answer: A

Explanation:

This graph is from HPLC. The area under the peak is proportional to the concentration. It is a standard process to make a calibration curve.

Question 8

Answer: C

Explanation:

The peaks have to be positive ions –this rules out A and B
The peaks have to add correctly to 15, 29 and 31 – this makes C correct, CH_3^+, $C_2H_5^+$, CH_2OH^+

Question 9

Answer: A

Explanation:

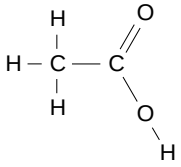
Enzymes have a specific active site which can only bind with a particular substrate due to the shapes of both molecules.

Question 10

Answer: C

Explanation:

This is ethanoic acid. It has no splitting and two different hydrogen environments. Ethanol will not have a peak with a shift as large as 11. Propanol will have more peaks.

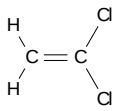


Question 11

Answer: D

Explanation:

The monomer must have a double bond and it must have two chlorine atoms on the one carbon atom. This is D.



Question 12

Answer: D

Explanation:

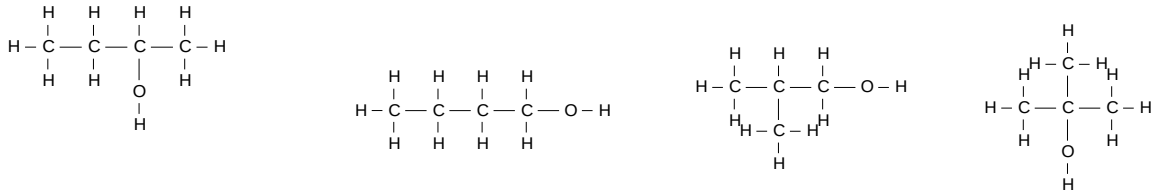
The substitution process can continue, and chlorines can be replace all H atoms if in excess.

Question 13

Answer: C

Explanation:

The 4 isomers are drawn

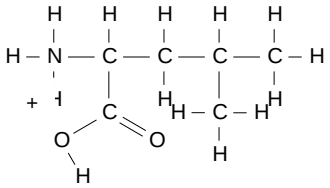


Question 14

Answer: A

Explanation:

The molecule matches leucine (check your data book) but it has an extra proton so it is in acid conditions



Question 15

Answer: C

Explanation:

The sugar ferments to ethanol. The canola produces oil. Put ethanol and oil together gives biodiesel.

Question 16

Answer: C

Explanation:

Electrons always flow from anode to cathode. The polarity of the electrodes always remains the same it is just the process that changes. During discharge when the anode will be negative and oxidation will occur. During recharge the electrode itself remains negative but the process will change to reduction and it will be the cathode.

Question 17

Answer: B

Explanation:

$$\begin{array}{ccccc} 2HI(g) & \rightleftharpoons & H_2(g) + I_2(g) & & \\ 0.034 & & 0 \quad\quad 0 & & \text{start} \\ & & 0.008 \quad\quad 0.008 & & \text{eq} \end{array}$$

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

$$K = 0.008 \times 0.008/0.018^2 = 0.198$$

Question 18

Answer: C

Explanation:

Energy = C.F. x ΔT = 93.0 x (20.4 – 15.0) = 502 J
E = c x m x ΔT
c = E/(m x ΔT) = 502/ (80.0 x (100 – 20.4)) = 0.0789 J/(g.°C)

Question 19

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 20

Answer: D

Explanation:

Options A (O_2), B (O_2) and C (Cl_2) will all produce gas at the anode. Option D will not produce a gas as the copper anode will cause the oxidation of copper to occur.

Question 21

Answer: B

Explanation:

n(butane) = 1/58 = 0.01724 mol
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 22

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

$S(g) + O_2(g) \rightarrow SO_2(g)$ $\Delta H = -297$ kJ mol^{-1}
$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$ $\Delta H = -198$ 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 23

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 24

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 25

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 26

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 27

Answer: D

Explanation:

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

Question 28

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 29

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 30

Answer: A

Explanation:

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

SECTION B : Short-answer questions

Question 1
*An * indicates the allocation of 1 mark*

a. **i.** $C_2H_5OH(aq) + H_2O(l) \rightarrow CH_3COOH(aq) + 4H^+(aq) + 4e$ *

ii. $Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$ *

1 + 1 = 2 marks

b.

i. There would be a colour change from orange to green*

ii. ratio of $Cr_2O_7^{2-}$ to C_2H_5OH is 2: 3
=> n(ethanol) = 3/2$n(Cr_2O_7^{2-})$ = 3/2 x 0.346 = 0.519 mol*

1 + 1 = 2 marks
Total 4 marks

Question 2

a. $K = [NH_3]^2 / [N_2][H_2]^3$

1 mark

b. i. $[NH_3] = 0.68/5 = 0.14$ M; $[N_2] = 0.54/5 = 0.11$ M; $[H_2] = 1.24/5 = 0.25$ M*
$K = (0.14)^2/ [0.11 \times (0.25)^3] = 11.4\ M^{-2}$*

2 marks

ii. No*, the concentration fraction is too low, therefore the reaction still needs to move to the right to increase the value*.

2 marks

c. i.

		N_2	H_2	NH_3
Initial		1.45 mol	2.64 mol	0 mol
Change		-0.31	-0.93	+0.62
Equilibrium		1.14 mol	**1.71 mol***	**0.62 mol***

2 marks

ii. $[NH_3] = 0.62/5 = 0.12$ M; $[N_2] = 1.14/5 = 0.23$ M; $[H_2] = 1.71/5 = 0.34$ M*
$K = (0.12)^2/ [0.23 \times (0.34)^3] = 1.59\ M^{-2}$*

2 marks

iii. The reaction is exothermic* as the K value has decreased with an increase in temperature. The reaction has moved in the reverse direction, increasing the reactant concentrations and decreasing the K value*.

2 marks
Total 11 marks

Question 3

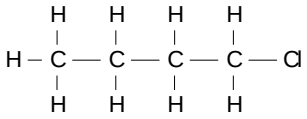
a.

A	**B**	**C**
Gen: $C_nH_{2n+1}Cl$	**Gen:** $C_nH_{2n+2}O$	**Gen:** $C_nH_{2n}O_2$

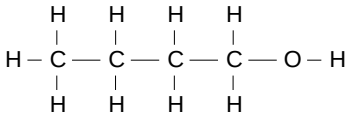
3 marks

b.

A.



B.



2 marks

c. 74 g corresponds to propanoic acid, therefore Compound A is 1-chloropropane, C_3H_7Cl*

1 mark

d. The molecule formed in Box B belongs to a homologous series.

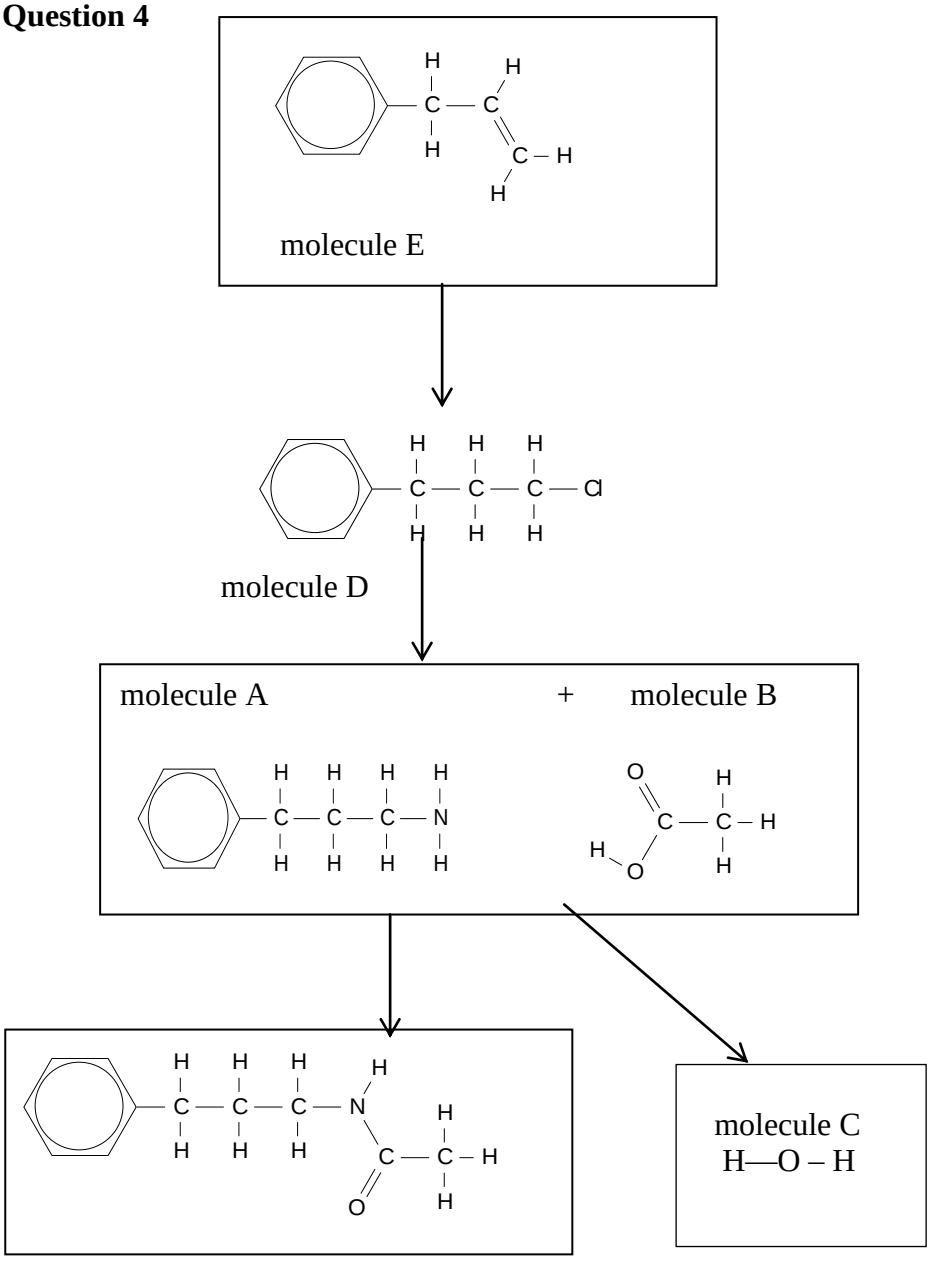
i. alkanols *

ii. 14, as each member of a homologous series has an extra $–CH_2–$ added to it. *

1 + 1 = 2 marks

Total 8 marks

Question 4



a.

i. refer to box* A

ii. molecule B refer to box *

iii. Another molecule, molecule C, refer to box *

1 + 1 + 1 = 3 marks

b. molecule D drawn in flowchart *

1 mark

c. Molecule E is drawn at the top of flowchart*.

1 mark

Total 5 marks

Question 5

A 2.840 g sample of an organic molecule is found to contain 60.0 % carbon by mass and 26.7 % oxygen. The remaining element present is hydrogen.

a.

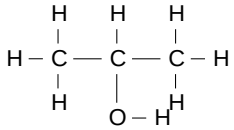
i. $n(C) : n(H) : n(O) = \frac{60}{12} : \frac{13.3}{1} : \frac{26.7}{16} = 5 : 13.3 : 1.67$ *

$= \frac{5}{1.67} : \frac{13.3}{1.67} : \frac{1.67}{1.67} = 3 : 8 : 1 = C_3H_8O$ *

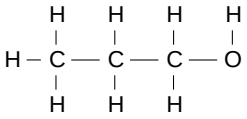
ii. C_3H_8O has a molar mass of 60 g*

2 + 1 = 3 marks

b.

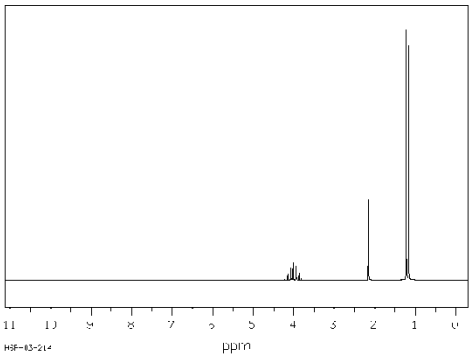


2 – propanol *



1- propanol *

2 marks

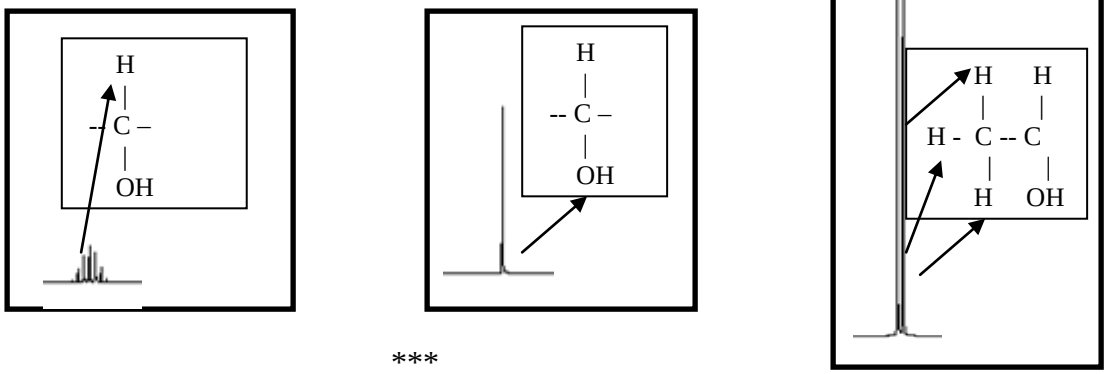


c.

i. 3 *

ii. 2-propanol *

iii.



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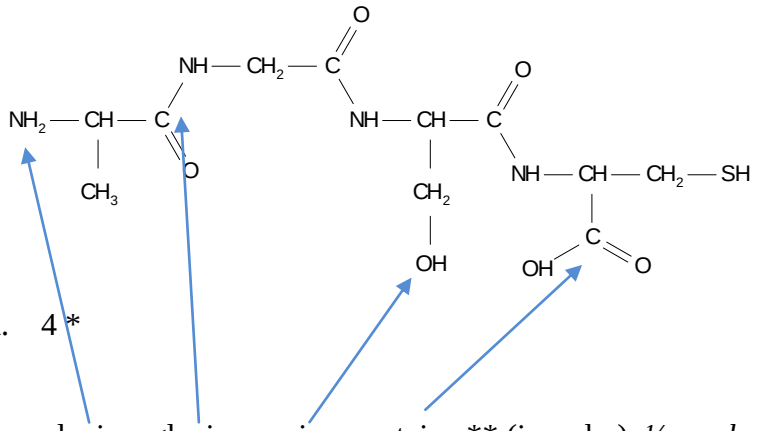
iv. 7 * as there are 6 neighbouring hydrogen atoms; using n + 1 rule makes 7

1 + 1 + 3 + 1 = 6 marks

Total 11 marks

Question 6



a. 4 *

1 mark

b. alanine, glycine, serine, cysteine ** (in order) *½ mark each correct answer*

2 marks

c. 3 *

1 mark

d. amino, amide, hydroxyl, carboxyl ** *½ mark each correct answer*

2 marks

Total 6 marks

Question 7

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 8

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 9

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) = $d \times V$ = 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 10

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

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

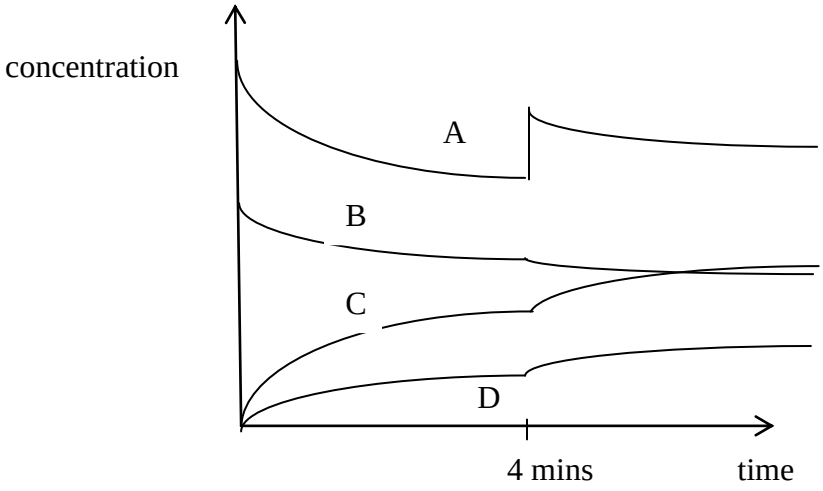
ii. The yield might be satisfactory at 250 ^{0}C, higher temperatures cost more money*, high temperatures can be dangerous.

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
Total 10 marks

Question 11

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

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

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

1 + 3 + 1 = 5 marks

b. $Q = It = 0.23 \times 6 \times 60 = 82.8$ C *

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

$n\text{Cu} = \frac{1}{2} n_e = 4.3 \times 10^{-4}$

$mass = n \times M = 4.3 \times 10^{-4} \times 63.5 = 0.028$ g *

3 marks

c. $n\text{O}_2 = \frac{1}{4} n_e = \frac{1}{4} \times 8.6 \times 10^{-4} = 2.15 \times 10^{-4}$ *

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

2 marks

d. $n\text{Cu}^{2+}$ (start) $= c \times V = 0.4 \times 0.1 = 0.04$ mol
$n\,\text{Cu}^{2+}$ (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