



Criterion 2

Markers were looking for clear expression, the use of units, states, reasonable significant figures and legibility. There was a strong correlation between marks on criterion 2 and the other criteria although it was possible for candidates scoring t on a particular criterion to do quite well on criterion 2. The best 6 questions were used to arrive at an assessment.

Criterion 7

Questions 1 and 2 were generally well answered, most scores falling between the range $\frac{8}{20}$ and $\frac{15}{20}$.

Question 1

- (a) Many candidates didn't use appropriate half-equations to derive the net final equation. Candidates tried to use $\text{KmnO}_4 + \text{HCl} \rightarrow \text{Cl}_2 + \text{H}_2\text{O}$!
- (b) (i) Quite good, although many did not recognize that there were 2 ClO_3^- and so included 11 e^- in the half-equation.
(ii) Poorly attempted - many simply rewrote their answer to (b) (i).
- (c) Quite good although many candidates simply said that F has a stronger attraction for electrons without explaining why.
- (d) Mostly ok but a lot of candidates stated that H and O changed their oxidation states.
- (e) Poorly answered or not attempted at all. Candidates often restated the question as the answer: "... because the acid is concentrated".

Question 2

- (a) Well answered. Disappointing to see how few candidates were competent with using directed numbers (ie. $-0.13 - -2.38 = 2.51$?)
- (b) Good – most recognized that a precipitate was forming; many failed to explain why a voltage was not recorded. Candidates needed to mention the lack of movement of ions.
- (c) Nearly all correct. Some indicated that the anode was the electrolyte $\text{Mg}(\text{NO}_3)_2$ instead of the metal electrode and made the same mistake for the cathode.
- (d) Good answers, although many did not calculate the E^0 value (or did so incorrectly).
- (e) Generally ok. A lot of candidates indicated that sodium is "soluble" in water rather than saying that the metal reacts with water.

Question 3

Most candidates answered this question correctly. Many wrote worded answers rather than using chemical equations. There was confusion of terms such as oxidizing agent. Many candidates forgot to compare the corrosion of untreated iron with Zn/Fe and Sn/Fe costing them 1 mark. Some candidates had very well structured answers. Nearly all candidates used the term sacrificial anode rather than sacrificial coating but were not penalized for this. Some termed the processes as electrolytic. Many wrote a lot for this question.

Question 4

- (a) Nearly everyone gave correct answer.
- (b) Mostly correct.
- (c) Only one point was required but some wrote an essay.

Question 5

- (a) The difficulties with this question were- with Cl_2 production over O_2 production at the anode.
 - with adding E^0 values incorrectly
 - with putting the reduction of Na^+ and with wrong E^0 values for some. Many candidates scored full marks for this part of the question.
- (b) This was a most contentious question in that water was electrolysed at both electrodes. Candidates who used the $\text{H}_2\text{O}/\text{H}_2$ equation used the $n(e^-): n(\text{H}_2\text{O})$ at the cathode as 1:1. Candidates who used the $\text{H}_2\text{O}/\text{O}_2$ equation had a ratio of $n(e^-): n(\text{H}_2\text{O})$ equal to 1:2. Candidates also used a mix of formulae to arrive at a 2:3 ratio.

All of these variations were awarded full marks.

- (c)
 - (i) The main error was to neglect to mention O_2 at the anode with the reduction of H^+ at the cathode.
 - (ii) Answers usually correlated with (i). Successful efforts mentioned the change to the voltage to 1.23 V.
 - (iii) Very well done by nearly all candidates. Spelling of platinum was often "platinum". Lack of time did seem to be a factor for many candidates.

Criterion 8

Questions 6-12 produced a very large spread of marks. These were the most difficult questions on the paper in that candidates could not rely on mere recall but had to apply principles to answer the questions in unfamiliar contexts. The misuse of Le Chatelier's principle abounded. Candidates assumed every reaction that was mentioned was an equilibrium situation and this led to some ridiculous answers such as heating concentrated acids before diluting them. Teachers need to get the message across that Le Chatelier's principle cannot be used indiscriminately.

Question 6

- (a) (i) Few candidates gave reasons for evaporation being an endothermic process. The single candidate who pointed out that the phase change involved an increase to the potential energy of the molecules received a bonus mark. It was pleasing that some candidates referred to the cooling effect of evaporating alcohol to justify their answer.
- (ii) Many candidates talked about bond formation being an exothermic process and scored _ a mark. Some reason that if ionization of F^- is endothermic then the reduction of a F atom must be exothermic.
- (b) Generally poorly answered. Only about 10% candidates referred to energy considerations. Most received half marks for referring to electron configurations.
- (c) Energy storage is a poorly understood concept. Almost half of candidates said that energy was released as bonds were broken. Almost all candidates said that energy was stored in bonds.

Two quite different answers were given full credit. One involving enthalpy, discussed the sum of chemical potential energy (as a result of interaction between molecules and electrons and the nuclei) and the kinetic energy due to the translation, rotation and vibrations of the molecules.

The alternative answer regarded ammonia as a fuel. The energy needed to break the bonds in ammonia is much less than the energy released when products are formed. \square Energy must have been “stored” in the molecules.

Question 7

Less than half of candidates recognized the need to slowly add the acid to the water. Many candidates talked about mixing small quantities at a time to limit the rate at which heat was produced or suggested that some means of cooling be used.

Question 8

This was well answered by the majority of candidates. Some wrongly reasoned that KOH had weak bonds and that $Na_2S_2O_3$ had much stronger bonds rather than comparing the relative strengths of bonds in reactants and products. It was disappointing to see answers that showed the breaking of the covalent bonds in anions as a result of dissolving.

Question 9

- (a) Well answered by most candidates. Some candidates incorrectly applied Le Chatelier’s principle, LCP.
- (b) Most candidates recognized a dramatic increase in the reaction rate but failed to explain it satisfactorily. The heat from the exothermic reaction is able to sustain the reaction above a critical temperature slightly higher than x . Some candidates said the reaction had come to equilibrium and stopped!
- (c) Most candidates wrongly referred to light acting as a catalyst. Those who went on to explain how a catalyst works got some credit for this.

Question 10

- (a) Some candidates removed water from the equation.
- (b) Reduction in value often given but with little explanation. A number of candidates linked increase in temperature with decrease in concentration.
- (c) Very few candidates noted that all concentrations would be lower than the initial values. Some drew good diagrams /graphs to illustrate answers.
- (d) Most wrongly thought that the value of K would change.
- (e) A number put too much information in their answer. A surprising number wanted to “open the lid and test for O₂ using a glowing splint”.

Question 11

A small number of candidates worked out that Cu was the limiting reagent. Many thought the reaction involved equilibrium and used LCP to construct the answer.

Question 12

- (a) Most left in [AgCH₃COO_(s)]
- (b) An overwhelming number of candidates had extra solid dissolving by applying LCP.
- (c) Many had extra Ag⁺ ions entering solution to accompany extra CH₃COO⁻ ions.
- (d) Many candidates said that extra water would have no effect. And that concentration would be half the original value.

Criterion 9

Questions 13-16 were very well done with a significant fraction of candidates scoring 16 or more out of 20 marks. It was disappointing that candidates did not include states or use units appropriately.

Question 13

Mostly well done although some candidates labelled (A) as butan-1-al. For B, butanone was the preferred answer but butan-2-one was accepted. The best answers to (c) mentioned C_nH_{2n+2}O or C₄H₁₀O for a saturated linear alcohol.

Question 14

- (a) Not well done. A lot of candidates did not understand the term hydrolysed when applied to esters.
- (b) (i) Well done
- (ii) Best answer used bromine test as an easily performed experiment with an unambiguous result.

Question 15

- (a) Well done.
- (b) Very well done! More care needed with units.
- (c) Not done so well. Some candidates picked arsenic from the periodic table. Others said butanol despite the reaction in (b) being acid-base!

Question 16

- (a) Quite well done. Expected mention of the unusual nature of the carbon-carbon bond for full marks.
- (b) Well done. Some candidates forgot that the logical third product was water. Too many candidates did not include the phases of reactants and products.

Questions 17 – 20 were not answered well. In general the standard of answers dealing with questions about gases or the periodic table were not as well understood as the questions on organic chemistry. This may reflect the time allocation given by teachers for the different topics.

Question 17

- (a) A large number of candidates gave the electron configuration of the calcium atom instead rather than for an ion of calcium.
- (b) Many candidates offered some form of explanation based on the difference in size of the atoms but few acknowledged differences in nuclear charges and the shielding of valence electrons by electrons in completed lower energy orbitals.
- (c) Generally well answered.
- (d) Many candidates could not provide an equation for strontium oxide reacting with water. The production of dissolved oxide ions and the production of hydrogen gas was disturbingly common.

Question 18

- (a) The two apparently contradictory statements caused considerable confusion. For many candidates. The few that recognized the limited solubility of oxygen in water generally went on to offer a reasonable answer.
- (b) The fact that there were only two unlabelled jars of gas available was overlooked by the majority of candidates. Any sensible testing that differentiated between the three gases was ultimately taken as acceptable for full marks. A number of candidates assumed an unlimited supply of each of the gases and designed tests accordingly. Far too many candidates believed that a match would continue to burn in an atmosphere of pure nitrogen.

Question 19

- (a) (i) Most candidates recognized that an ester form, with most acknowledging the catalytic action of the sulfuric acid. Although asked for in the question, appropriate answers were not always given. A balanced molecular equation was expected rather than a word equation. Since this was allocated three marks, some simple explanation of how a catalyst functions was expected for full marks.
- (ii) A small number of candidates gave an equation for the reaction AND recognized that it was an acid-base reaction. The inability to write a balanced equation was far too common as was the belief by many that ammonia has the formula NH_4 rather than NH_3 .
- (b) Recognizing that the sulfuric acid was the electrolyte for the acid battery was expected.

Question 20

- (a) Most candidates recognized the inert nature of the gas hence its likelihood to go unnoticed.
- (b) To be successful in this question, candidates need to recognize that all the gases mentioned were noble gases and that the slightly more reactive ones were in fact the larger atoms. The comments in 17 (b) above are relevant here too. There were a few very high quality answers given.

Criterion 10

Questions 21 –25 were generally answered exceptionally well with a large number of candidates scoring maximum marks or very close. Common mistakes were as follows:

Question 21

- (a) A number of candidates equated one mole with one atom and gave their answer as 3.99×10^{-23} . Others divided the mass by N_A instead of multiplying.
- (b) Well answered. No units were required but were frequently given.
- (c) Well answered but unnecessary errors introduced by rounding off too much during the calculation.
- (d) Standard temperature often taken as 298 K. Still some reference to °K (degrees Kelvin are wrong).

Question 22

Extremely well answered. Main errors introduced by excessive rounding off before obtaining mole ratio.

Question 23

Quite a few candidates applied the mass of barium sulfate to magnesium sulfate and also calculated molar masses incorrectly.

Question 24

- (a) The relationship between n , c and V was often wrong.
- (b) Many candidates did not like getting a negative pH value for their answer and disputed the possibility.

Question 25

Assigning the charge on an aluminium ion as $+1$ was common. Another error was taking $n(\text{Al}) = 3 n(e^-)$ instead of vice versa.

Candidates tackled questions 26-29 very well but it was obvious that some ran out of time on question 29. Criterion 2 for these questions was of a very high standard.

Question 26

- (a) The most common error was assigning the molar mass of hydrogen gas as 1.0 rather than 2.0 g mol^{-1} .
- (b) The vast majority of candidates obtained the correct answer using their $n(\text{H}_2)$ from (a). It was pleasing to see the number of candidates who showed how to calculate an answer in this part without having attempted (a).

Question 27

- (a) The Hess's law question was very well done although logical processes were lacking in some cases.
- (b) Only one candidate correctly divided by Avogadro's number to get the energy for a single bond rather than a mole of single bonds.

Question 28

The lack of the use of a balanced equation was worrying. The use of $c_1V_1 = c_2V_2$ was also of concern.

Question 29

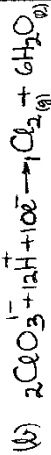
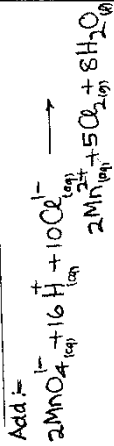
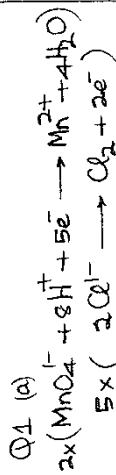
- (a) Well done.
- (b) About half of the candidates recognized that the answer to part (a) was only for the 25 mL sample and failed to multiply by 250 / 25.

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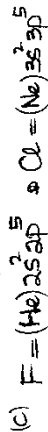
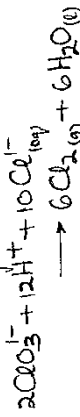
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CHEMISTRY 12C (CH956)
ICE EXAMINATIONS NOV. 2003
ANSWER SUMMARY

CRITERION 7.



Thus adding =

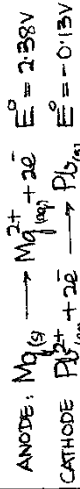


Both react by e^- gain (they are oxidisers) but the F atom with a smaller atomic radius is a stronger e^- attractor than chlorine. \therefore F is more reactive \therefore F = stronger oxidiser!

(d) Cl_2 ox (Cl) = 0 } Thus
 Cl^- ox (Cl) = -1 } chlorine is
 $HOCl$ ox (Cl) = +1 } being
 oxidised to +1 and reduced to -1 \therefore this is a REDOX REACTION!

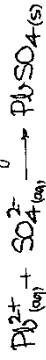
(e) The E° values are for standard state conditions which implies ionic concentrations = 1.0 mol l⁻¹. Conc. HCl has $[H^+] \approx 11$ mol l⁻¹. \therefore not standard state. $\therefore E^\circ$ table doesn't necessarily apply!

Q2. (a)

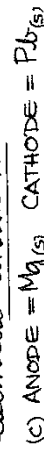


NET CELL VOLTAGE = 2.25 V

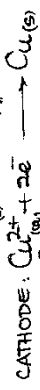
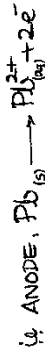
(b) The Pb^{2+} react with and form a precipitate with the sulfate ions in the salt bridge \therefore



This leaves the salt bridge without a conducting pathway of mobile ions. \therefore Voltage = 0 because no electrical circuit now exists.



(d) Cu^{2+} ions are stronger oxidisers than Pb^{2+} thus, now copper becomes the cathode & lead the anode



Now the current will flow Pb (ANODE) \rightarrow Cu (CATHODE) whereas previously it flowed Mg (ANODE) \rightarrow Pb (CATHODE) \therefore current has reversed!

Q2 (e) Comparing E° values for Sn/Sn^{2+} and Pb/Pb^{2+} we see a difference of only 0.01V \therefore this cell gives a very low EMF. \therefore zero voltage expected

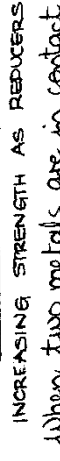
(f) The sodium metal, would immediately react (explosively) with the aqueous electrolyte into which it was immersed. $\therefore 2Na(s) + 2H_2O(l) \rightarrow 2NaOH + H_2(g)$

Q3. Sn , Fe , Zn

INCREASING STRENGTH AS REDUCERS When two metals are in contact in a corrosive environment, the more powerful reducer will be oxidised and the other metal becomes the cathode and is thus protected.

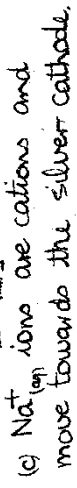
$Zn|Fe$ \therefore Zn corrodes and acts as a sacrificial anode, thus protecting the Fe . ($Zn \rightarrow Zn^{2+} + 2e^-$)

$Sn|Fe$ \therefore Fe corrodes & protects the tin. The Fe in this case corrodes even faster than the Fe on its own due to the EMF generated by the electrochemical cell formed by the metals in contact.



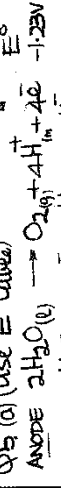
Q4

(a) ANODE $Pb(s) \rightarrow Pb^{2+}(aq) + 2e^-$
 (b) As the lead anode undergoes oxidation, producing more lead ions $\rightarrow [Pb^{2+}]$ will increase!
 (c) Na^+ ions are cations and move towards the silver cathode.



As the cell operates the silver ions are used up and as their concⁿ approaches zero the cell voltage also drops to zero. ($E_{cell} = 0$)
 * Also surface area of Pb (anode decreases too)

Q5 (a) (Use E° table)



(NET) $E^\circ = -2.06V$
 \therefore Min. voltage needed = 2.06V

(b) from 10.0g of water, mass of H_2 released = $(10.0 \times \frac{2.0}{18.0}) = 1.11g$

Now mass $H_2 = (\frac{A(H) \times I \times t}{Z \times 96500}) g$

$\therefore t = (\frac{1.11 \times 1 \times 96500}{2 \times 1 \times 1.50})$ seconds

\therefore Time needed = 7.15×10^4 seconds = 20 hours (2 SF)

(c) (i) anode is the same as above but cathode $\frac{1}{2} eq$ is $2H^+ + 2e^- \rightarrow H_2(g)$ $E^\circ = 0V$

(ii) NET E° now is -1.23V \therefore Only 1.23 volts now needed (as a minimum) for electrolysis.

(iii) Inert anode is especially important \therefore use $Pt(s)$ or $C(s)$? (* use $Pt(s)$ for both)

CRITERION 8.

Q6.

(a) (i) $C_2H_6O(g) \rightarrow C_2H_6O(g)$
 This is endothermic because energy is required to break the bonds between molecules and separate them into the gaseous state.

(ii) $F(g) + e^- \rightarrow F^-(g)$
 Exothermic because this involves the formation of a bond between the atom and the added electron. It achieves a lower EP state. \therefore EXO!

(b) $H + H \rightarrow H_2$ achieves a lower energy state where the attractive forces exceed the repulsions. \therefore this exothermic process is favoured and H_2 molecules form spontaneously. But... He atoms when in contact have greater repulsive forces than attraction. \therefore a lower EP state is not achieved and thus $He + He \rightarrow He_2$ is not a favoured energy change.

(c) The bonds in NH_3 are comparatively weak bonds and when NH_3 forms new compounds (eg. NO_2 & H_2O) the new bonds formed are strong and thus

release more energy than was required to break the original $N-H$ bonds
 $\therefore NH_3$ can be thought of having energy (chemical) stored in its (weak) bonds!

Q7.
 Add small quantities of the conc. HNO_3 at a time to a larger volume of icy cold water. This prevents the water getting so hot that it boils and ejects the acid.
 Have the water to which the conc. acid is added sitting in an ice bath.
 Carry out the process slowly!!

Q8. $KOH(aq) \rightarrow K^+ + OH^-$ (STEP 1)
 $K^+ + OH^- \xrightarrow{H_2O} K^+(aq) + OH^-(aq)$ (STEP 2)
 In this case, the energy required to separate the solid into its ions in step 1 ("lattice energy") is small but the energy released when the ions are "hydrated" in step 2 is much larger. \therefore the net effect is energy is released (EXO)
 For Na_2SiO_3 , the opposite must be the case i.e. More energy is required to separate the ions than is released when the ions are hydrated \rightarrow ENDO!

Q9. (a) An increase in temperature results in a greater number of collisions between H_2O_2 molecules (due to inc. E_k)
 The collisions are also more energetic \therefore a greater proportion of collisions have E_k 's sufficient to overcome the reaction's activation energy barrier (E_a)
 \therefore more effective collisions
 \Rightarrow greater reaction rate.

(b) When T is greater than X the rate increases dramatically and further temp. increases have little effect. \therefore above X it appears that practically all collisions are effective and thus the rate is exceedingly great!

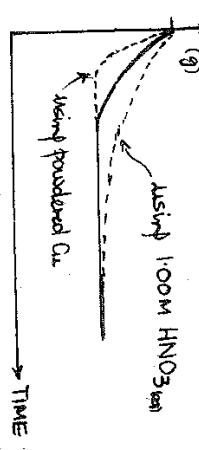
(c) Sunlight is a form of energy and w. light has photons with sufficient energy to break chemical bonds which may then lead into reactions occurring! (eg $3O_2 \xrightarrow{w.} 2O_3$)

Q10. (a) $K_c = \frac{[H_2O(aq)]^2 [CO_2(aq)]^2}{[H_2C(aq)]^4 [O_2(aq)]}$ (M^{-1})
 (b) CHANGE - raise temp
 EFFECT - system attempt to $T \downarrow$
 RESULT - reverse reaction fav.
 \therefore more HCl & O_2
 $\therefore K_c$ DECREASES.

(c) CHANGE $P \uparrow$
 EFFECT system favours reverse reaction. \rightarrow more HCl & O_2
 \therefore reactant conc's increase & product conc's decrease.

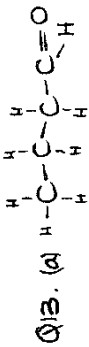
(d) K_c unaffected ($T = \text{constant}$)
 Changes in pressure, colour, temperature are all possibilities

Q11. $n(Cu) = 0.15g \text{ mole (limiting reactant)}$
 (a) If acid is only $\frac{1}{2}$ as concentrated \therefore slower reaction but same mass of NO_2 given off. (see graph below)
 (b) Large surface area. \therefore much faster reaction due to increased no. of effective collisions!

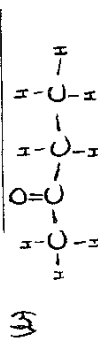


Q12. (a) $K = \frac{[Ag^+(aq)] [CH_3COO^-(aq)]}{[AgCH_3COO(s)]}$
 (b) Ionic conc's unaffected as solution is already saturated with the silver ethanoate. \therefore no more dissolves.
 (c) System adjusts so as to partially remove the added ethanoate ions by favouring reverse reaction. $\therefore [Ag^+(aq)]$ decreases
 (d) Adding water causes more solid $AgCH_3COO$ to dissolve thus $n(Ag^+) \uparrow$
 $n(Ag^+)_{D} > n(Ag^+)_{A}$

CRITERION 9.



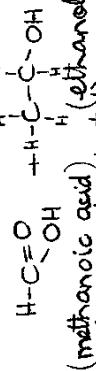
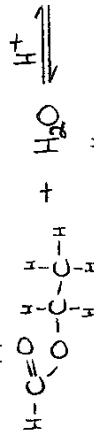
(butanal)



(butanone)

(c) No! Saturated straight chain alcohols have molecular formulae $C_nH_{2n+2}O$
 $\therefore C_4H_{10}O_1$ not $C_4H_8O_1$

Q14 (a)



(methanoic acid) (names not expected)

(b) "saturated" fat or oil is one with only "C-C" single bonds within the carbon chain
 "polyunsaturated" = carbon chain includes several "C=C" double bonds.

(ii) A polyunsaturated oil will react rapidly with Br_2 solution giving a change from brown to colourless. cont...

Q14(b)(ii) continued. The saturated fats and oils do not undergo this rapid addition reaction with Br_2 .

Q15.

(a) reaction with sodium
 \therefore alcohol or carboxylic acid functional groups likely to be present

Gas evolved = $H_2(g)$
 (b) compound = carboxylic acid as indicated by the pH being ≈ 3 .
 $n(NaOH)$ needed = molarity $\times L$
 $= 0.160 \times 30.4 \times 10^{-3}$
 $= 4.86 \times 10^{-3}$ mole

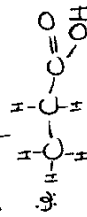
$\therefore n(HX) = (4.86 \times 10^{-3} \times 1)$ mole
 Now moles = $\frac{\text{mass}}{M_r}$
 $\therefore 4.86 \times 10^{-3} = \frac{0.360}{M_r}$
 $\Rightarrow M_r(HX) = \frac{0.360}{4.86 \times 10^{-3}}$
 $= 74.0$

\therefore molar mass of compd = 74.0 g.mol⁻¹

(c) Carboxylic acids = $C_nH_{2n}O_2$

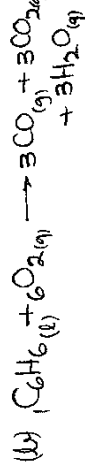
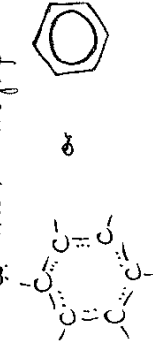
Thus $M_r(C_nH_{2n}O_2) = 74.0$
 $\therefore (12n + 2n + 32) = 74.0$
 $\therefore n = 3$

\therefore compound is $C_3H_6O_2$



\therefore propanoic acid.

Q16. (a) C_6H_6 is a 6 membered carbon ring with 1 H atom attached per carbon. The bonding between carbon atoms is neither true single nor double bonds: It involves delocalised π \therefore interchanging "1.5" type bonds

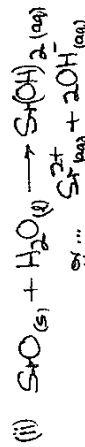


Q17. (a) $Ca^{2+} = 4s^2 3d^2 3p^6 3s^2 3p^6 = (Ar)$

(b) The 4s² electrons in calcium's valence orbital are further from the nucleus and thus more weakly attracted than the 3s² valence e⁻ in magnesium atom.
 \therefore these 4s² electrons are more easily lost \Rightarrow Ca is more reactive

(c) (i) atomic radius = larger
 (ii) reducing strength = greater

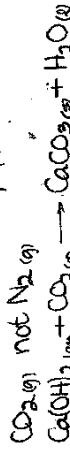
(d) (i) $SnAt_2$



Q18. (a) $O_2(g)$ does have measurable solubility in water but it is sufficiently low to result in very small losses when collected over $H_2O(l)$

Aquatic plants and animals survive on the small (but adequate) level of $O_2(g)$ that does dissolve in water.

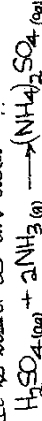
(b) Place a glowing splint in each. The splint will reignite in the jar of O_2 . Then bubble samples of the other 2 gases through limewater. A milky ppt indicates



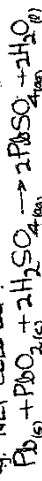
Q19. (the catalyst is H^+ from H_2SO_4)

(a) (i) a catalyst for ester formation:
 $\text{H}-\text{C}-\text{C}=\text{O} + \text{HO}-\text{C}-\text{O}-\text{C}-\text{H} \xrightarrow{H^+} \text{H}-\text{C}-\text{C}(\text{O}-\text{C}-\text{O}-\text{C}-\text{H})-\text{O}-\text{C}-\text{H} + \text{H}_2\text{O}$

(ii) The ester formed is methylmethanoate. The catalytic action involves deprotonation. It is used as an acid.



(iii) In car batteries H_2SO_4 is used as the electrolyte as well as an acid.



Q20. Argon gas is inert \therefore it

couldn't be removed from the atmosphere by chemical reactions and thus identified in a new compound

(b) He & Ne have their valence e⁻ very near their nuclei \therefore their outer e⁻ are very hard to remove (they have very high ionization energies). Both also have "filled" completed valence orbital configurations too. This also accounts for their inert nature.

CRITERION 10.

Q21.

(a) 1 atom = 3.99×10^{-23} g
 \therefore 1 mole of atoms = 3.99×10^{-23} g
 = $(3.99 \times 10^{-23} \times 6.02 \times 10^{23})$ g
 = 24.0 g

molar mass of X = 24.0 g/mol
 $\therefore A_r(X) = 24.0$

(b) $A_r(Cu) = \left(\frac{71.5}{100} \times 63\right) + \left(\frac{28.5}{100} \times 65\right)$
 = $45.0 + 18.5$
 = 63.5 (or 63.6)

(c) $P = 101.3$ kPa
 $V = 1.56$ L
 $n = \left(\frac{P \cdot V}{R \cdot T}\right)$ mole
 $R = 8.31$
 $T = 298$ K
 $PV = nRT$

$\therefore 101.3 \times 1.56 = \frac{202 \times 8.31 \times 298}{M_r}$

$\therefore M_r = \left(\frac{202 \times 8.31 \times 298}{101.3 \times 1.56}\right)$
 = 31.7

\therefore Mr of the gas is 31.7
 or molar mass = 31.7 g mol⁻¹

(d) $P = 1$ atm
 $V_1 = 574$ mL
 $T_1 = 273$ K
 $P_2 = 1$ atm
 $T_2 = 270$ K
 $V_2 = ?$
 Thus $V_2 = V_1 \times \frac{T_2}{T_1} = 574 \times \frac{270}{273}$
 \therefore New volume = 568 mL

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Q22. Empirical formula gives the ratio of moles of atoms:

$\therefore n(C) : n(H) : n(O)$
 = $\left(\frac{52.0}{12.0}\right) : \left(\frac{13.0}{1.00}\right) : \left(\frac{35.0}{16.0}\right)$
 = $4.33 : 13.0 : 2.19$
 = $2 : 6 : 1$

\therefore empirical formula is C_2H_6O

Q23. $n(BaSO_4)$ ppt. = $\frac{\text{mass}}{M_r}$
 = $\left(\frac{1.37}{233.4}\right)$
 = 5.87×10^{-3} moles

$\therefore n(MgSO_4) = (5.87 \times 10^{-3})$
 = 5.87×10^{-3} mole
 \therefore mass of $MgSO_4 = (\text{moles} \times M_r)$ g
 = $5.87 \times 10^{-3} \times 120.4$ g
 = 0.707 g.

Q24. $n(Al) = \frac{\text{mass}}{M_r} = \left(\frac{10.0}{27.0}\right)$
 = 0.370 mole
 $\rightarrow n(HCl)$ needed = $(0.370 \times \frac{6}{2})$
 = 1.11 mole

Now
 litres of HCl needed = $\left(\frac{\text{moles}}{\text{molarity}}\right)$
 = $\left(\frac{1.11}{0.100}\right)$
 = 11.1 L

\therefore Volume of HCl needed = 11.1 L
 (b) $pH = -\log[H^+]$
 = $-\log(6.00)$
 = -0.78
 * Assume 100% ionised

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Q25.

mass of Al = $\left(\frac{A_r(Al) \times I \times t}{z \times 96500}\right)$ g
 = $\left(\frac{27.0 \times 10.0 \times 3 \times 3600}{3 \times 96500}\right)$
 = 10.1 g
 \therefore mass of Al deposited = 10.1 g

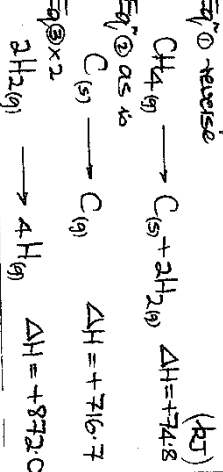
NOTE: * 1 mole H_2 releases 242 kJ

Q26. $n(H_2)$ needed = $\frac{1000 \text{ kJ}}{242 \text{ kJ/mole}}$
 = 4.13 mole

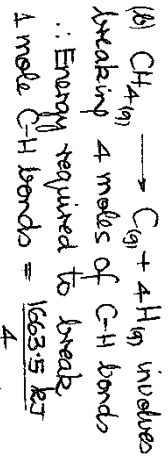
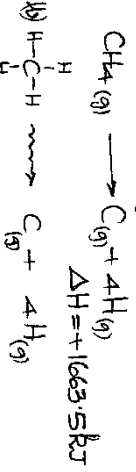
\therefore mass of $H_2(g) = (\text{moles} \times M_r)$ g
 = 4.13×2.00 g
 = 8.26 g

(b) 1 mole $H_2(g)$ occupies 22.4 L at STP
 $\therefore 4.13$ mole $H_2(g)$ occupies (22.4×4.13) L
 \therefore Volume $H_2(g) = 92.6$ L @ STP

Q27. Apply Hess's Law:



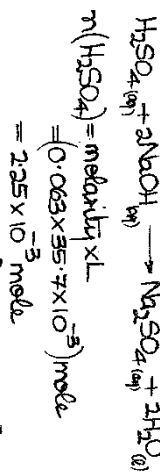
Adding (Hess's Law) gives:



Thus per C-H bond energy needed = $\left(\frac{416}{6.02 \times 10^{23}}\right)$ kJ
 = 6.91×10^{-22} kJ

NB: Answer * is all that was expected!

Q28.



$\therefore n(NaOH) = (2.25 \times 10^{-3} \times 2) = 4.50 \times 10^{-3}$ mole
 \therefore Molarity of NaOH = $\frac{\text{moles}}{L} = \frac{4.50 \times 10^{-3}}{25.0 \times 10^{-3}}$
 $\therefore [NaOH] = 0.180$ mol L⁻¹

Q29. $n(G_2O_7^{2-}) = 0.12 \times 20.8 \times 10^{-3}$
 = 2.50×10^{-3} mole
 $\therefore n(Fe^{2+}) = (2.50 \times 10^{-3})$
 = 0.0150 mole

\therefore mass of Fe^{2+} ions = (0.0150×55.8) g
 = 0.84 g (2.5F)
 (b) 0.84 g Fe^{2+} in the 25.0 mL sample
 $\therefore 8.4$ g Fe^{2+} in 250 mL

Thus, percentage $Fe^{2+} = \left(\frac{8.4}{41.7} \times 100\right)\%$
 = 20% (2.5F)