CH856

Chemistry

2002 External Examination Report

General Comments

There were 526 candidates who entered the examination for CH856 this year and the overall standard was very pleasing.

The examination was regarded as a little easier than last year's and this was partly due to the questions being more along the line of the expected "standard question" types. This was particularly the case in criterion 10 where the calculation questions were done very well indeed, with many candidates gaining close to full marks.

Criterion 7

Question 1

This question was arguably the easiest in the entire examination, but very few candidates actually scored full marks on the question.

(a)   About one third of candidates stated the oxidation number of N as $+3$ instead of -3 in NH_3.
(b)   As a result of (a) most of the candidates who had incorrectly assigned the oxidation number above stated that NH_3 was reduced to N_2.

A common error in the whole section was the confusion between an ionic charge and an oxidation number. Frequently candidates asserted that oxygen was reduced to O^{2-} in H_2O, or that it was the species N^{3-} in ammonia which was oxidized to N (not N_2)

Question 2

This question was generally well done, and most candidates were comfortable with the conventions required.

(a)&(b) Common errors here included the omission of the 1- charge on the NO_3^- ion. Consequently the number of electrons required for balancing was also incorrect.
(c)   Some confusion reigned here over the relative positions of HCl and Cu on the Electrochemical Series. It was often asserted that Cu was a stronger oxidizer than HCl, when perhaps candidates often actually meant Cu^{2+}.
(d)   The NO_3^- ion does not appear on the Electrochemical Series in the approved text, but nonetheless candidates could deduce from the highest oxidation state of nitrogen in the ion that it was probable that it would oxidize Fe^{2+} to Fe^{3+} under appropriate conditions. In fact many candidates said precisely this.

Question 3

This question was very well done, with the majority of candidates being comfortable with the sign conventions and the construction of an electrochemical cell. Most common errors which occurred included:

(i)   inclusion of a battery in the external circuit;
(ii)   inappropriate choice of salt bridge. For example, $KMnO_4$ $_{(aq)}$ was a puzzling favourite here, as was $CuSO_4$ $_{(aq)}$;
(iii)   the view that carbon was oxidized at the anode and went into solution as C^{4+} ions.

Question 4

Few candidates treated Na and I_2 as elements, and quoted the reasons for their choice as being "higher up" or "lower down" on the electrochemical series rather than as a more/less powerful oxidizer or reducer. Many candidates failed to look for competition for electrons, and so failed to recognize the reduction of H_2O at the cathode, instead asserting that Na^+ is reduced.

Question 5

(a)   Some candidates mentioned the use of an indicator in this titration, and others asserted that the end-point could best be assessed when CO_2 was no longer evolving.
(b)   Some candidates thought that $Na_2C_2O_4$ was titrated as a solid, and frequently incorrectly ascribed the oxalate ion as $C_2O_4^{1-}$ instead of $C_2O_4^{2-}$.
(c)   Frequent errors in this subsection included:
        (i)   failure to use the mole ratio from the overall equation in (b);
        (ii)   failure to convert volumes to litres;
        (iii)   failure to present the calculation in clearly identifiable steps which made it hard for markers to assign marks in the case of partially correct answers.
        Candidates who had incorrect mole ratios from (b) were not penalized if their calculations were correct on data used.

Question 6

This question highlighted the following common misconceptions and errors:
(i)   frequent use of an inappropriate anode e.g. Pt or Cu;
(ii)   frequent drawing of diagrams which were electrochemical rather than electrolytic (see the corresponding errors in Q.3)
(iii)   keys were often only partially immersed; (penalty under Cr 2)
(iv)   ionic equations were not provided;
(v)   failure to explain and include a diagram.

Question 7

(a)   (i)   Although not stated, the answer would require the inclusion of appropriate half-equations;
        (ii)   The role of 'salt' to enhance electrical conductivity on poles was rarely mentioned;
        (iii)   Some candidates asserted the formation of Fe^{2+} instead of Fe^{3+};
        (iv)   Some candidates thought this was a "wet" v. "dry" scenario.

(b)   (i)   Many good explanations were given without relevant equations;

      (ii)   The fact that the composition of steel is mainly iron was often omitted, and candidates frequently stated that "steel is oxidized…";

      (iii)   A minor point was that the steel structure was there for support, and the role as a sacrificial anode is not its purpose.

Criterion 8

(a)   Well answered by 99% of candidates

(b)   Generally well done although many candidates forgot to explain why it was exothermic.

Question 9

(a)   Not well answered. Most candidates didn't realise that 1 mole of H_2SO_4 contains 2 moles of H^+

(b)   Very poorly answered. Many candidates left it blank or guessed at the answer.

Question 10

(a)   Poorly done by many candidates as they either didn't write the equation or even if they did, they thought the reaction had 2 H-H bonds and 2 F-F bonds breaking.

(b)   Many candidates made silly mistakes with the molar mass for HF and many candidates got an answer of –271 kJ as they just halved the answer from (a) not realising their answer from (a) was generally for 2 moles of HF.

Question 11

(a)   Generally well done although many candidates think that the match had the activation energy rather than sufficient energy to overcome it. Most candidates only mentioned that it provided energy to overcome the E_a and forgot to mention why it was only required to start the process.

(b)   Well done

(c)   Many candidates thought if a reaction is spontaneous then it has no E_a

Question 12

Most candidates did not give the correct equation for the ionisation of water. Many candidates assumed it was oxidation or reduction of water.

Question 13

(a)   The vast majority of candidates lost half a mark because they included the concentration of water in the K_c expression. Other common errors involved:
- leaving out the ionic charges on the chromate and dichromate ions.
- omitting the exponents for the chromate and hydronium ion concentration terms.
- giving the reciprocal K_c expression.

(b)   Although the question was relatively straight forward, many candidates failed to see it as one involving the disruption of the equilibrium through the removal of the acidic hydronium ions. Le Chatelier's

Principle (often spelt Principal) provided a correct means of establishing the result of this change being the formation of more yellow chromate ions. Common errors included:

- thinking an 'alkaline solution' contributed more H_3O^+ ions rather than removed them.
- regarding the reaction as 'redox' and stating that the dichromate ions would be reduced to the green aqueous Cr^{3+} ions.
- saying the solution would turn *blue* as this was a common colour associated with indicators in alkaline solutions!
- displaying uncertainty and declaring that the colour would be a 'muddy' or 'yellowy/orange' colour.

Question 14

(a)   This generally well done although a significant number of candidates gave a detailed summary of catalysis but didn't refer it to *equilibrium* systems as the question asked. A surprising number said (correctly) that it has no effect on the position of equilibrium but then said that the catalyst only increased the rate of the forward reaction.

(b)   This was well done and usually tackled by the correct application of Le Chatelier's Principle.   Some candidates failed to recognise that there was a difference in number of mole of gaseous reactants and products and thus said that there was no change in the position of equilibrium.

(c)   Fairly well done. The most common mistakes related to:
- having sudden rises in all three concentration rather than just methanol.
- having sudden drops in the ethene and water concentrations.
- not having the steepest slope of the concentration graphs nearest the point A.
- showing the methanol concentration decreasing to less than its original equilibrium value.
- graphs drawn without a ruler and thus being very hard to interpret.

Candidates who showed the relative changes in concentration as '+x', '+2x' and '-2x' gained special recognition as bonus marks in terms of criterion 2.

Question 15

(a)   The key factor was the increased (~5x) concentration of oxygen not the surface area of the iron as many said. Full marks required reference to the increased number of effective collisions and its effect on the rate.

(b)   To gain full marks, candidates needed to mention that the temperature increase resulted in increased average E_K for reactant particles and subsequently:
- a greater number of collisions between reactant particles per unit time and
- more energetic collisions (i.e. greater combined E_P after collision)
- greater likelihood of particles undergoing effective collisions (overcoming the E_a barrier)

(c)   Most recognised MnO_2 as being a catalyst and answered this part correctly. However, an alarming number of candidates referred to the catalyst as "magnesium dioxide M_gO_2!" Energy diagrams were welcomed although there was inadequate space available.Page 5 of 9Chem Exam 2002 Comments Collated

(d)   The increased surface area and thus greater possible reactant sites in kindling was well discussed.

Criterion 9

Question 16

This question revealed a number of common errors with respect to nomenclature: e.g.
- not assigning carbon number 1 as the end carbon nearest the functional group.
- not using a location number for the functional group e.g. "-1-ol"
- confusing the ketone (heptan-4-one) as an ester. This may well have been as a result of the way the structure was presented.

Question 17

Generally well answered, particularly parts (a) and (b).
(c)   (i)   Some continued using methanol although the question specified ethanol. This was penalised only half a mark.
        (ii)   Many were unable to name the sodium salt correctly.

Question 18

(a)   Errors occurred where candidates failed to use all the information correctly. Although A was correctly identified as a primary alcohol, compound B was often identified as a ketone or even as an enol. Many candidates named the compound but didn't give its structural formula as required. Where functional groups were shown as structures, often some bonds were omitted.
(b)   Some found this question confusing in that some texts (e.g. Bucat) suggest that an aldehyde is not oxidised to the corresponding carboxylic acid by acidified dichromate whereas experimental evidence reveals the opposite to be true. Naming the organic product was often missed or became difficult if B had been incorrectly identified. Many candidates missed the fact that the reduction half equation for the $Cr_2O_7^{2-}/H^+$ is in the textbook.
(c)   (i)   This was quite well done. There were many isomers possible and the choice of these influenced the ease of answering part (ii).
        (ii)   Candidates were able to say how the different isomers might react but often omitted the practical details and the likely observations.

Question 19

(a)   This was very well done. The expected answer was $(Ne)3s^23p^5$ but 2)8)7 was also acceptable.
Both parts (b) and (c) were very well done.
(d)   Well done. Candidates had difficulty in explaining why chlorine formed ions more easily than astatine. They did not mention the effect of electron screening or distance of the orbitals from the nucleus in their answer. Many candidates tried to use ionisation energy or electronegativity in their answers. These answers often highlighted their lack of understanding.
(e)   Surprisingly, this was done poorly. Candidates were not aware that astatine occurred as a diatomic molecule. Many candidates did not include the physical states or gave the incorrect states. Typical errors included:

$$Rb^+_{(s)} \quad + \quad At^-_{(g)} \quad \Diamond \quad RbAt_{(s)}$$
$$Rb_{(s)} \quad + \quad At_{(g)} \quad \Diamond \quad RbAt_{(aq)}$$
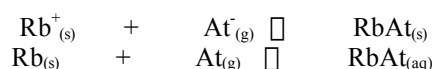
Question 20

(a)   (i)   Well done. Using the Kinetic Theory for Gases candidates were able to successfully explain how the tyre's increase in temperature resulted from friction between the tyre and the road. This temperature rise caused an increase in the number of gas particle collisions and hence pressure in the tyre. However, the answer required candidates to mention that the pressure rise was due to the tyre's volume not altering.

         (ii)   Poorly done. Very few candidates were able to explain that the can's denting was due to a difference in pressure between the inside and outside of the can. Very few candidates mentioned that the cooling resulted in the pressure dropping not only because of the temperature decrease but also due to the condensing of petrol vapours.

(b)   Well done. Candidates obtained full marks by stating that below –20°C carbon dioxide may have become wholly (or partly) liquid or solid. Both possibilities were acceptable.

(c)   Poorly done. Candidates obtained half marks by stating that at high altitudes the low temperatures may cause the CO_2 to be in the liquid or solid phase. Few candidates discussed the comparative densities of air and CO_2 which was the key point of the question.

Criterion 10

Overall the vast majority of candidates achieved very well on these questions. Full marks were awarded to many candidates. The average mark was about 15 out of a possible 19 marks. Significant figures were disappointing even among candidates who achieved full marks for their calculations. Units were often left out of final answers and states were not recorded for the equation. Only a handful of candidates produced a perfect solution.

Question 21

(a) $M = 310.4$ g mol^{-1}
       Many candidates gave the molar mass of P as 39.0 instead of 31.0 However, if the working was shown, candidates still received half a mark.

(b)   % P = 9.98 %
       If the answer was consistent with part (a) full marks were awarded. If the answer found the % S by mistake, half marks were awarded if working was shown.

Question 22

(a) Cl_2O
       A lot of silly errors were made such as dividing by 12.0 g mol-1 for chlorine and doing all the right working only to finish up with the ratio ClO_2. Once again marks were awarded for consistent working.

(b) $Na_2CO_3.7H_2O$
       About 10% of candidates calculated the molar mass of Na_2CO_3 and then didn't know how to proceed. This was awarded 1 mark.
       A considerable number of candidates found the molar mass of Na_2CO_3 .$1H_2O$ to be 124 g mol^{-1} and concluded that there must be 6 waters of hydration. Good working was awarded 2 out of 3 marks.

Question 23

(a) number = 3.3×10^{22} particles
A minority of candidates recognised that the pressure restricted the final answer to 2 significant figures. A common error was not changing the pressure to kPa before calculating n.

(b) T = -6°C
Many candidates forgot to convert the absolute temperature to degrees Celsius or made an error by subtracting the wrong number to give a positive temperature. Only a handful of candidates recognised that this answer was only to 1 digit. It was disappointing to see so many errors in transforming the ideal gas equation.

Question 24

(a) $(NH_4)_2Cr_2O_{7(s)}$ ◊ $N_{2(g)}$ + $_4H_2O_{(g)}$ + $Cr_2O_{3(s)}$
Half a mark was deducted for a small error in balancing the equation such a producing two nitrogen atoms instead of a molecule of nitrogen.

(b) m = 15.0 g
One mark was deducted for a major error such as calculating the wrong molar mass for ammonium dichromate or getting the wrong ratio of water. If the answer was consistent with a wrong equation from part a), full marks were still awarded.

Question 25

(a) Well done by a majority of candidates. A number of candidates left the total volume in mL and a surprisingly large number stated that:
   concentration = moles x litres

(b) Well done by a large majority. The main error was calculating the pH of one of the three initial solutions.

(c) Very few candidates attempted to write an equation. Most who did had some fairly imaginative products (NCl3 was popular). Many did not give any indication that *the moles of HCl = the moles of NH₃*. The majority of candidates put the three numbers into the calculator and got the correct answer. A 1:1 stoichiometric ratio was a big help to many!

Question 26

(a) Reasonably well done by most. Common mistakes included not indicating that ΔH would be negative and miscalculation of the molar mass of ethanol. A significant number thought the molar heat was 63.0 kJ and calculated from that what the heat release would be for 2.00 g.

(b) Very poorly answered. A small number of candidates had the right idea when attempting this question. Many of those thought the 44 kJ referred to 3 moles of water.

Question 27

(a) Well done by most, but many candidates put the numbers into the formula and got the answer. This led to confusion when attempting part (b). Common errors included incorrect charge for zinc ions, leaving the volume in mL, using the molar mass of zinc sulfate and 5 minutes as 1,800 seconds.

(b) A reasonable number of candidates arrived at the right answer, but many put a lot of work into it. Many calculated the initial and final (!) masses of zinc sulfate.

Overall scores were not as high as for questions 21 to 24. The scripts fell into 2 distinct groups – those that could answer the problems quite well and those that had a lot of difficulties. Not many mid-range scores.

Criterion 2

Guidelines

1.   Show the states (solid, liquid, gaseous or aqueous) in balanced equations.
2.   In problems involving multiplication or division, work to the least number of significant figures. When addition or subtraction is involved work the least number of decimal places. Too many candidates shortened their working numbers down to one significant figure and then gave final answers with more than five significant figures.
3.   Make sure that you include appropriate units in your final answer.
4.   When carrying out calculations in an answer, give explanations as to what the data are related to. Many started calculations without any indication as to what the calculation was about.
5.   Give properly presented answers; e.g. Mass of zinc deposited = 0.122 g

CH856 CHEMISTRY '12C'
TCE EXAMINATIONS NOV. 2002
ANSWER SUMMARY:

Q1. (CRITERION 7)

(a) NH_3 OX(N) = 3-
N_2 OX(N) = 0
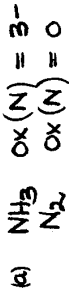
(b) ammonia (NH_3) has been oxidised to N_2 gas
∴: $2NH_3 \longrightarrow N_2 + 6H^+ + 6e^-$ (OXID^N)

(c) Oxygen has been reduced to water
∴: $O_2 + 4H^+ + 4e^- \longrightarrow 2H_2O$ (RED^N)

Q2

(a) $NO_3^{1-} + 2H^+ + e^-$
$\longrightarrow NO_2 + H_2O$ (REDUCT^N)

(b) $Cu_{(s)} \longrightarrow Cu^{2+}_{(aq)} + 2e^-$ (OXID^N)

NET:
$Cu_{(s)} + 2NO_3^{1-}_{(aq)} + 4H^+_{(aq)}$
$\longrightarrow Cu^{2+}_{(aq)} + 2NO_{2(g)} + 2H_2O_{(l)}$
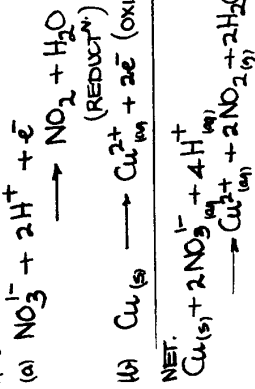
(c) In $HCl_{(aq)}$ the oxidising agent is $H^+_{(aq)}$ (Cl^{1-} is a reducer) and H^+ is a weaker oxidiser than Cu^{2+} ∴ H^+ won't oxidise $Cu_{(s)}$

(d) The NO_3^- is a sufficiently strong oxidising agent to oxidise Fe^{2+} to Fe^{3+}, thus iron(II) nitrate spontaneously

changes into $Fe(NO_3)_3$ ie: iron(III) nitrate.

Q3.

(a) anode : oxidation ½ equation.
∴: $Cu_{(s)} \longrightarrow Cu^{2+}_{(aq)} + 2e^-$ $E^° = -0.34V$

(b) cathode : reduction ½ equation.
$Fe^{3+}_{(aq)} + e^- \longrightarrow Fe^{2+}_{(aq)}$ $E^° = +0.77V$

(c) $Cu_{(s)} + 2Fe^{3+} \longrightarrow Cu^{2+}_{(aq)} + 2Fe_{(aq)}$
$E^°_{NET} = +0.43V$
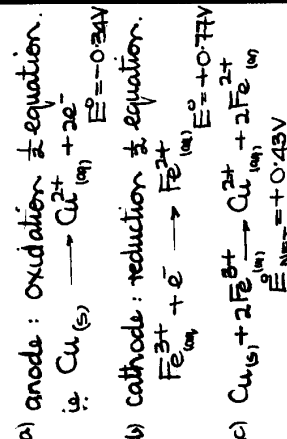
(d) Salt bridge : use $NaNO_3_{(aq)}$ as $Na^+_{(aq)} \& NO_3^{1-}_{(aq)}$ are spectator ions (won't undergo redox reactions and won't allow the formation of precipitates when other ions flow through the salt bridge.
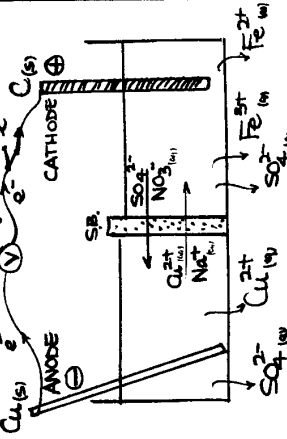
e⁻ flow: anode → cathode.
anions ($NO_3 \& SO_4^{2-}$) flow → anode
cations ($Cu^{2+} \& Na^+$) flow → cathode

(f) Maximum voltage = +0.43V (see part (e) above)

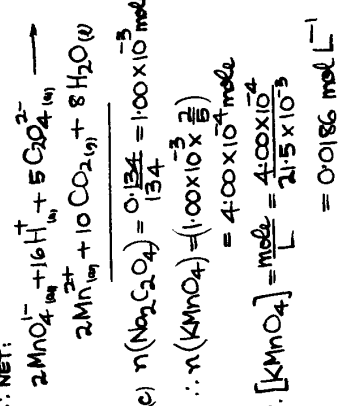**Q4.** (CR. 7 - CONT.)

At the anode, iodide ions are oxidised to iodine because $I^-_{(aq)}$ are stronger reducers than water (see ECS)

∴ ANODE :
$2I^-_{(aq)} \longrightarrow I_{2(aq)} + 2e^-$

At the cathode, water is reduced because water is a stronger oxidiser than Na (see ECS)
∴ CATHODE :
$2H_2O_{(l)} + 2e^- \longrightarrow H_{2(g)} + 2OH^-_{(aq)}$
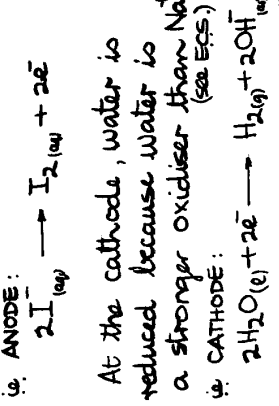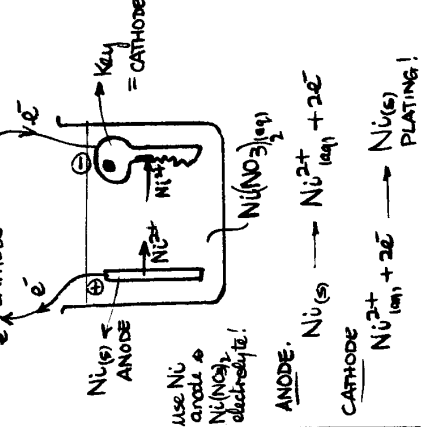
Q5.

(a) at the end-point, the MnO_4^{1-} has no more oxalate to react with and thus the purple colour persists rather than being reduced to colourless Mn^{2+}

(b) $MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$
$C_2O_4^{2-} \longrightarrow 2CO_{2(g)} + 2e^-$

∴ NET:
$2MnO_4^{1-}_{(aq)} + 16H^+_{(aq)} + 5C_2O_4^{2-}_{(aq)} \longrightarrow$
$2Mn^{2+}_{(aq)} + 10CO_{2(g)} + 8H_2O_{(l)}$

(c) $n(Na_2C_2O_4) = 0.\underline{134} = 1.00 \times 10^{-3}$ mol
$\quad\quad\quad\quad\quad 134$
∴ $n(KMnO_4) = (1.00 \times 10^{-3} \times \frac{2}{5})$
$= 4.00 \times 10^{-4}$ mole

∴ $[KMnO_4] = \underline{mole} = \underline{4.00 \times 10^{-4}}$
$\quad\quad\quad\quad\quad L \quad\quad 21.5 \times 10^{-3}$
$= 0.0186$ mol L^{-1}

Q6.

Key
= CATHODE

$Ni_{(s)} \rightarrow ANODE$
use Ni anode & $Ni(NO_3)_2$ electrolyte!

ANODE:
$Ni_{(s)} \longrightarrow Ni^{2+}_{(aq)} + 2e^-$

CATHODE:
$Ni^{2+}_{(aq)} + 2e^- \longrightarrow Ni_{(s)}$ PLATING !

(use nickel(II) nitrate as the aqueous electrolyte)

Q7

(a) When iron corrodes ($Fe \rightarrow Fe^{3+} + 3e^-$) the process is accelerated by an electrically conducting 'salt bridge' ∴ seashore provide salt → faster corrosion. The reduction ½ equation is:
$2H_2O_{(l)} + O_{2(aq)} + 4e^- \longrightarrow 4OH^-_{(aq)}$
At depth → $[O_{2(aq)}] \simeq$ zero ∴ no reduction occurs and so no oxidation occurs ∴ minimal corrosion!

(b) Two metals in contact ∴ more powerful reducing agent ($Fe > Cu$) is oxidised preferentially ie:
$Fe_{(s)} \longrightarrow Fe^{3+} + 3e^-$ and reduction occurs on the surface of the Cu
ie: $2H_2O_{(l)} + O_{2(aq)} + 4e^- \longrightarrow 4OH^-_{(aq)}$
∴ $Cu_{(s)}$ doesn't corrode!

CRITERION 5.

Q8.

(a) Exothermic = a chemical reaction where heat energy is RELEASED. (ΔH = (-ve))

(b) If the energy required to break the chemical bonds in the reactants is less than the new energy released when the new bonds form in the products, then there is an overall (net) release of energy ∴ EXOTHERMIC.

Q9.

(a) $H_2SO_{4(aq)} \rightarrow 2H^+_{(aq)} + SO_4^{2-}{}_{(aq)}$ is fully dissociated (strong acid)

Each mole of $H_2SO_{4(aq)}$ to release 2 mole of $H^+_{(aq)}$ ions.

When 2 mole H^+ is neutralised

$\Delta H = -56\cdot2 \times 2 = -113\cdot2 \ kJ$

This is in agreement to 3 s.f. with the observed heat released.

(b) If the organic acid was monoprotic (HX) the energy release (42 kJ) instead of 56·6 kJ is due to the acid being 'weak' and ≈ 15 kJ per mole of energy needed to dissociate the acid ie:

$HX_{(aq)} \longrightarrow H^+_{(aq)} + X^-_{(aq)}$ $\Delta H = +15 \ kJ$

ie. Energy is required to dissociate the HX molecules. (break bonds)

Q10. (a) $H_2 + F_2 \longrightarrow 2HF$

Bonds broken
Total energy reqd = 436 + 156 = + 592 kJ

Bonds Formed
Total energy released = -2×567 = $-1134 \ kJ$

Thus, net energy release is
$\Delta H = -1134 + 592 = -542$ kJ per 2 mole of HF.

(b) $n(HF)$ formed $= \dfrac{10\cdot0}{20\cdot0} = 0\cdot500$ mol

∴ Energy released = 135 kJ.

Q11.

(a) The reaction has a relatively high activation energy barrier and thus no collisions between petrol and O_2 molecules are effective. A spark or match raises the E_k of reactants and thus now some collisions are effective → reaction occurs ∴ heat released → further collisions effective ∴ chain reaction → explosion? ie. v. fast reaction now occurs.

(b)

(CRITERION 6)

Q11 (c)

A low Ea barrier would make most collisions between reactant molecules 'effective' ∴ reaction would occur spontaneously at room temp. (see dotted line of previous diagram)

Q12. $H_2O_{(l)} \rightleftharpoons H^+_{(aq)} + OH^-_{(aq)}$

$K_w = [H^+_{(aq)}][OH^-_{(aq)}]$

Kw is 50 times greater at 90°C than is greater ∴ the conc of ions is greater
(both $[H^+]$ & $[OH^-]$ are about 7× more than they are at 25°C)

∴ more ions → better electrical conductor!

Q13.

(a) $K_c = \dfrac{[CrO_4^{2-}]^2[H_3O^+]^2}{[Cr_2O_7^{2-}]}$ NB. $H_3O^+ = H^+$

(b) CHANGE - add $OH^-_{(aq)}$ (alkali)

EFFECT - OH^- reacts with and removes H_3O^+ (H^+)

RESULT system favours the forward reaction to partially replace H_3O^+ ∴ more CrO_4^{2-} → more YELLOW!

Q14 (a) Catalyst doesn't affect the yield of C_2H_4 and H_2O at equilm - it simply increases the rate of achieving equilibrium.

(b) CHANGE increase P_{TOTAL}

EFFECT system attempts to ↓ P_{tot}

RESULT equilm position shifts favouring $CH_3OH_{(g)}$ because of fewer moles of gas. 2mol ← 3mol
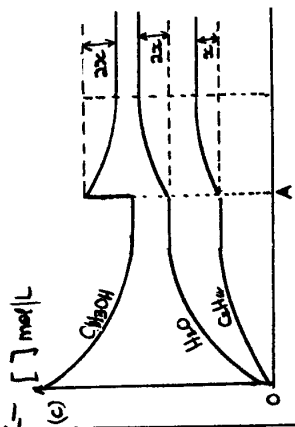
Q15.

(a) air ≈ 20% O_2 ∴ pure O_2 → 5× greater $[O_2]$ ∴ more collisions → greater reaction rate due to more EFFECTIVE collisions/sec!

(b) raise T ∴ E_k of $H^+_{(aq)}$ increase → more collisions and more energetic collisions per sec

$2H^+_{(aq)} + Fe_{(s)} \longrightarrow Fe^{2+}_{(aq)} + H_{2(g)}$

∴ greater proportion of collisions exceed the threshold energy and cross the Ea barrier ∴ FASTER

(c) MnO_2 = catalyst for

$2H_2O_{2(aq)} \rightarrow 2H_2O_{(l)} + O_{2(g)}$

The catalyst provides an alternative reaction pathway (mechanism) with a lower Ea barrier ∴ collisions that were previously ineffective may now be effective ∴ faster rate!

(d)

A greater surface area of contact between the fuel (wood) and O_2 gives more effective collisions for binding ∴ it burns faster

CRITERION 9

Q16. 3-methylbutan-1-ol
heptan-4-one

Q17.
— reacts with Na ∴ alcohol or carbox. acid
neutral pH ∴ not c.acid
→ alcohol

(a) functional group '-OH'

(b) 1 carbon atom ∴ $H-\overset{H}{\underset{H}{C}}-OH$ i. methanol

(c) $H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-OH + Na \longrightarrow H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-ONa + \frac{1}{2}H_2{(g)}$
salt = sodium ethoxide

Q18.
(a) compound 'A' is a primary alcohol
$H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-OH$ propan-1-ol
propan-1-ol with functional group being the -OH alcohol group.

Compound B is an aldehyde
$H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{O}{\overset{\|}{C}}{}^{-H}$ propanal
B contains the aldehyde $(-\overset{O}{\overset{\|}{C}}{}^{-H})$ functional group.

(b) $C_3H_6O_1 + H_2O \rightarrow C_3H_6O_2 + 2H^+ + 2e^-$

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

NET

$3C_3H_6O_1{(aq)} + Cr_2O_7^{2-}{(aq)} + 8H^+{(aq)} \longrightarrow 3C_3H_6O_2{(aq)} + 2Cr^{3+}{(aq)} + 4H_2O{(l)}$

The product is $C_3H_6O_2$ or propanoic acid

(c) butanal , butanone

(ii) butanal would undergo oxidation with (say) acidified KMnO₄(aq) and the KMnO₄ would change in colour from purple to colourless(pink). The ketone (butanone) will not undergo oxidation with H⁺/MnO₄⁻ ∴ purple colour will persist.

Q19.
(a) $Cl = (Ne) 3s^2 3p^5$

(b) $:\overset{\cdot\cdot}{Cl}:\overset{\cdot\cdot}{Cl}:$ Each Cl atom has 7 valence (outer) e⁻ and by sharing 1 pair → both Cl atoms achieve the stable octet arrangement as shown (Cl_2)

(c) $Cl = (Ne) 3s^2 3p^5$
$Cl^- = (Ar) = (Ne) 3s^2 3p^6$
- each Cl atom by gaining one electron thus achieves the completed outer orbital with the stable octet i.e. the e⁻ configuration of the noble gas argon.

(d) Both Cl and At react to form ions by gaining 1e⁻ as each has a 7e⁻ outer shell configuration and tend to gain 1e⁻ to achieve the octet.

The smaller radius of Cl attracts e⁻ more strongly than At ∴ Cl forms Cl⁻ more easily than At forms At⁻ ions.

(e) (i) At = solid at s.t.c.
(ii) HAt = acidic
(iii) At₂O = acidic oxide
(iv) Calcium astatide CaAt₂

(f) $2Rb{(s)} + At_2{(s)} \longrightarrow 2RbAt{(s)}$

∴ more frequent and more energetic collisions with the wall ∴ more force per unit area → greater pressure

(ii) During the day the vapour space in the top of the can becomes saturated with petrol vapours. When temp. drops some petrol vapours condense ∴ P↓ because $P = n(\frac{RT}{V})$ ∴ smaller 'n' → smaller P ∴ can is crushed by greater outside pressure than is inside!

(b) At -20°C (or less) the CO₂ molecules move more slowly ∴ van der Waals force may result in the gas behaving "non-ideally" or even condensing into a liquid.
NB To obey PV=nRT requires the gas to be "IDEAL" i.e have NO attractive forces between molecules.

(c) $M_r(CO_2) = 44$
$M_r(air) = 28.8$
∴ CO₂(g) is more dense than air ∴ CO₂ balloons will not rise in air because they are less buoyant.
Also CO₂(g) might liquify at upper atmospheric temperature

Q20.(a)(i) Tyre friction with the road → temperature of air in tyre increases ∴ av.E.k of O₂ & N₂ molecules increases →

CRITERION 10

Q21.

(a) $M_r(C_{12}H_{23}PS_2O_3)$
$= (12\times12.0) + (23\times1.0) + (1\times31.0) + (2\times32.1) + (3\times16.0)$
$= 310.2$ (or 310 to 3 S.F.)

(b) percentage phosphorus is
$\frac{31.0}{310} \times 100 = 10.0\%$ by mass

Q22.

(a) in 100 g of compound there is 81.6g chlorine & 18.4g of oxygen ∴ empirical formula is

$n(Cl) \; : \; n(O)$

$\frac{81.6}{35.5} \; : \; \frac{18.4}{16.0}$

$= 2.30 \; : \; 1.15$

$= 2 \; : \; 1$

∴ empirical formula is Cl_2O

(b) $M_r(Na_2CO_3 \cdot xH_2O)$
$= (2\times23.0) + (1\times12.0) + (3\times16.0) + x\times18.0)$
$= 106 + 18x$
But $106 + 18x = 232$ (given)
∴ $18x = 126$
$x = 7$
∴ hydrate is $Na_2CO_3 \cdot 7H_2O$ (x=7)

Q23.

$V = 0.150 L$ $PV=nRT$
$P = 900 kPa$
$T = 300 K$ ∴ $n = \frac{PV}{RT}$
$n = ? mole$
$R = 8.31$ $= \frac{(900\times0.150)}{(8.31\times300)}$

$n = 0.0542 mole$

∴ No. of particles $= 0.0542\times6.02\times10^{23}$
$= 3.26\times10^{22}$

$P_1 = 900 kPa$ $P_2 = 600kPa$
$T_1 = 300 K$ $T_2 = ?$
$V_1 = 0.150L$ $V_2 = 0.200L$

n constant ∴ $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$

∴ $\frac{900\times0.150}{300} = \frac{600\times0.200}{T_2}$

∴ $T_2 = \frac{(300\times600\times0.200)}{(900\times0.150)}$
$= 267 K$
∴ final temp is $(267-273)°C$
$= -6 °C$

Q24.

(a) $(NH_4)_2Cr_2O_7(s) \rightarrow Cr_2O_3(s) + 4H_2O(g) + N_2(g)$

(b) $M_r((NH_4)_2Cr_2O_7) = (2\times14.0) + (8\times1.0) + (2\times52.0) + (7\times16.0)$
$= 252$
∴ $n((NH_4)_2Cr_2O_7) = \frac{52.4}{252} = 0.208 mole$
∴ $n(H_2O)$ formed $= (0.208\times\frac{4}{1})$
$= 0.832 mole$
∴ mass of water $= 0.832\times18.0 g$
$= 15.0 g$

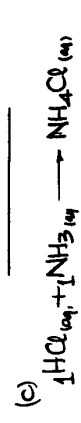(CRITERION 10)

Q25.

(a) $n = $ molarity × litres
$n(HCl)_1 = 0.500\times100\times10^{-3}$
$n(HCl)_2 = 0.250\times140\times10^{-3}$
$n(HCl)_3 = 0.100\times100\times10^{-3}$

∴ $n(HCl)_{TOTAL} = (5.00\times10^{-3}) + (35.0\times10^{-3}) + (10.0\times10^{-3})$
$= 50.0\times10^{-3}$
$= 0.0500 mole$ in a total volume of $(10+140+100)$
V equals 0.250L
∴ Final $[HCl_{(aq)}] = \frac{mole}{L}$
$= \frac{0.0500}{0.250}$
$= 0.200 mole/L$

(b) Assume 100% dissociation of the HCl → $[H^+_{(aq)}] = 0.200 mol/L$
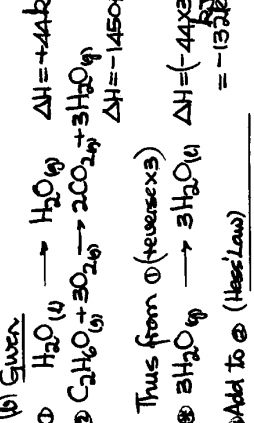→ $pH = -log(0.200)$
$= 0.700$ (3 S.F.)

(c)
$1HCl_{(aq)} + 1NH_{3(aq)} \rightarrow NH_4Cl_{(aq)}$
$n(HCl)$ used $= $ molarity × litres
$= 0.200\times28.6\times10^{-3}$
$= 5.72\times10^{-3} mole$
∴ $n(NH_3)$ reacted $= (5.72\times10^{-3}\times\frac{1}{1})$
$= 5.72\times10^{-3} mole$
in a volume of 25.0 mL
→ Conc of $NH_3 = \frac{moles}{L}$
$= \frac{5.72\times10^{-3}}{25.0\times10^{-3}}$
$= 0.2288...$
∴ $[NH_3_{(aq)}] = 0.229 mol L^{-1}$

Q26.

(a) $M_r(CH_3CH_2OH) = 46.0$
∴ $n(CH_3CH_2OH) = \frac{2.00}{46.0} mole$
$= 0.0435 mole$

Heat of reaction $\Delta H = \frac{kJ}{mole}$
(exo ∴ (-ve))
∴ $\Delta H = -\frac{(63.0 kJ)}{0.0435 mole}$
$= -1449 kJ.mol^{-1}$
$\Delta H = -1450 kJ.mol^{-1}$ (3 S.F.)

(b) Given
① $H_2O(l) \rightarrow H_2O(g)$ $\Delta H = +44 kJ$
② $C_2H_4O + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(g)$ $\Delta H = -1450 kJ$
Thus from ① (reverse ×3)
③ $3H_2O(g) \rightarrow 3H_2O(l)$ $\Delta H = (-44\times3)$
$= -132 kJ$
Add to ② (Hess' Law)
$C_2H_4O + 3O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$
$\Delta H = -1582 kJ$

Q27.

(a) mass of $Zn(s)$ = $\frac{(A_r(Zn)\times I\times t)}{z\times96500}$?
deposited $= \frac{65.4\times1.20\times5\times60}{2\times96500}$ g
$= 0.122 g$

(b) $n(Zn)$ removed $= (\frac{0.122}{65.4}) = 1.87\times10^{-3} mole$
$n(Zn^{2+})$ initially $= 0.0500 mole$
∴ $n(Zn^{2+})$ finally $= 0.0481 mole$ in 100mL
∴ Final $[Zn^{2+}_{(aq)}] = \frac{mole}{L} = 0.481 mol L^{-1}$