ASSESSMENT REPORT 2020

CHM415115 – CHEMISTRY

PART 1 - CRITERION 5

General Comments

Students found the criterion 5 section of the exam challenging. Some of the wording in the question stimulus appeared to confuse students, as their answers were often far removed from the intent of the questions. Some tolerance in answers was applied as outlined below in the comments section for each question. In addition, this year some leniency was given to answers that lacked some subscripts and accurate significant figures.

Question 1

A very simple question requiring the use of the information sheet in terms of the 'standard reduction potential table' and 'common coloured aqueous ions'. Many errors occurred relating to the observations to the electrochemical cell.

Question	Answer	Marks	Comments / considerations for 2020 exam
1a (i)	$MnO_4^-{}_{(aq)} + 8H^+{}_{(aq)} + 5e^- \rightarrow Mn^{2+}{}_{(aq)} + 4H_2O_{(l)}$	1	If Q1 a (i) and (ii) are swapped, then max 1 mark.
1a (ii)	$Ni_{(s)} \rightarrow Ni^{2+}{}_{(aq)} + 2e^-$	1	
1b	**In Beaker** Any two of: • The Ni will start to corrode/disappear • The Ni solution's green colour intensified. • The purple MnO_4^- solution fades/turns pink • Increase in pH of cathode **In external circuit** Ammeter reading will drop	1 1	Do not accept 'pale pink appears' Accept ecf if equations in Q1 (a) are wrong. ½ for drop in <u>voltage</u> of ammeter
1c	$Ni/Ni^{2+}// MnO_4^-,H^+/Mn^{2+}/C$	1	If missing a component = ½ If electrodes are not at the ends = ½ Accept 'graphite' for C No deduction for missing H^+
1d	1.74 V	1	

Question 2

This challenging question tested students' ability to calculate oxidation number and to interpret oxidation numbers in reactions. Part (a) required calculation of H, O and S oxidation numbers. Part (b) confused many students, and part (c) was answered correctly by just a few students. Part (c) was of particular note, as almost all students did not realise it required the calculation of sulfur's oxidation number.

Question	Answer	Marks	Comments / considerations for 2020 exam
2a	Ox No(S): +6 → +6. No change in oxidation number so not an oxidation reaction Ox No(O): -2 → -2. No change in oxidation number, or Ox No(H): +1 → +1. No change in oxidation number	1 1	
2b	Not at standard conditions.	1	Answers related to high concentration or different state accepted.
2c	Ox No(S in H_2S) = -2. Comparison to Ox No(S in SO_2) = +4, indicating I^- is a stronger reducer that Br^-	1 1	

Question 3

Students found this question to be very easy and most students scored well in all parts.

Question	Answer	Marks	Comments / considerations for 2020 exam
3a	$n(e^-)$ = (1.25 x 40 x 60)/96500	1	Accept (1.25 x 2400)/96500
3b	n(Pb) = ½ x 0.0311 = 0.0155 M(Pb) = 0.0155 x 207.2 = 3.22 g	1 1	Working not needed. Working not needed. 2 marks for correct answer. Accept use of $n(e^-)$ = 0.03, giving M(Pb) = 3.1 g
3c	Ag^+ reduction requires 1 e^- (rather than 2e^- for Pb), or n(Ag) = $n(e^-)$ M(Ag) approximately ½ M(Pb)	1 1	For 2 marks, accept correct calculation of mass of Ag formed (= 0.0311 x 107.9 = 3.4 g) Accept ecf.

Question 4

Students who were skilled at the use of the reduction potential table to calculate reaction E^o values should have scored well on this question. Unfortunately, this was rarely the case as the question wording tended to confuse most.

In part (a) a student who recognised that H_2S is an acid and forms H^+, which is then reduced to H_2 could have easily calculated a negative E^o value and gained full marks. However, this was rarely completed, and so alternate answers related to the nature of H_2S and Ag were accepted. Part (b) was a simple question, yet most answers related to the formation of an electrochemical cell. Part (c) again required comparison of E^o values, but again this was rarely done. The last two parts were generally well answered.

Question	Answer	Marks	Comments / considerations for 2020 exam
4a	Correctly used E^o calculations to show the reaction is not spontaneous E.g. EMF = -0.80 + 0 = -0.80 (neg), ∴ not spontaneous **Or**, Both Ag and H_2S are reducers Ag is not powerful enough reducer to reduce H^+	2 1 1	
4b	Allows flow of electrons, or Create electrical connection, or Complete (forms) the circuit	1	
4c	Aluminium can reduce Ag^+/Ag_2S As it is a powerful enough reducer, EMF = 1.71 – 0.69 = 1.02 V	1 1	
4d	$2Al_{(s)} + 3Ag_2S_{(s)} + 3H_2O_{(l)} \rightarrow Al_2O_{3(s)} + 6Ag_{(s)} + 3H_2S_{(g)}$ Ag_2S	1 1	½ mark for indication of Ag_2S reduction equation is multiplied by 3 Accept Ag^+ in Ag_2S, or Ag^+
4e	Electrolyte, or Provides ions	1	Accept role is to speed up reaction.

Question 5

An interesting question relating to the breakdown of nitrogen gas to form ammonia using electrolysis. There were several easy parts to this questions that were unfortunately poorly answered.

Part (a) was a fairly straight forward energy changes question that is found in the Physical Sciences course. Unfortunately, most students did not understand the question and gained no marks. Part (b) and (c) were completed well by many students. Part (d), which required students to outline competing equations due to the presence of water, was poorly answered. This may have been related to the absence of E^o values in the initial equation.

Question	Answer	Marks	Comments / considerations for 2020 exam
5a	Label left electrode (or half cell) anode and, right cathode Electrical energy to chemical (or bond) energy	1 1	Accept 'electrical energy used, to bond energy. (either breaking/forming/heat)
5b (i)	$2H_2O_{(l)} \rightarrow O_{2(g)} + 4H^+_{(aq)} + 4e^-$	1	
5b (ii)	$N_{2(g)} + 6H^+_{(aq)} + 6e^- \rightarrow 2NH_{3(g)}$	1	½ mark for incorrect balancing equation.
5c	Allow ion movement, or Separates the half cells, or	1	**Can accept:** • Maintain electrical neutrality, or • Prevent charge polarisation • Prevent product gases mixing
5d	A different reaction can occur. Water will be a competing reaction where $2H_2O_{(l)} + 2e^- \rightarrow 2OH^-_{(aq)} + H_{2(g)}$, $E^o = -0.83$ V	1 1	Indication that H_2O is a stronger oxidiser without equation = ½

Question 6

This question provided a substantial amount of stimulus material, which seemed to confuse many students. Part (a) and (c) were generally answered well, but part (b) clearly confused students, as many answers did not address the observations of pH change, O_2 release and Cl_2 release.

Part (d) requires some discussion here, as the situation described was that of two metals in contact in a damp environment with oxygen present. Students should have instantly recognised this as a situation of accelerated corrosion to the most reactive (or strongest reducer) metal. Strangely, many students did not provide equations, and many did not mention the presence of a weaker reducer. Subsequently, some students lost easy marks here.

Question	Answer	Marks	Comments / considerations for 2020 exam
6a	Anode = positive, Cathode = negative. Ni^{2+} moving right and Cl- (or SO_4^{2-}) moving left	½ ½	Do not accept movement of +/- ions (rather than Ni^{2+}, Cl^- or SO_4^{2-})
6b	Water will oxidise $2H_2O_{(l)} \rightarrow O_{2(g)} + 4H^+_{(aq)} + 4e^-$, forming bubbles of O_2 gas, and increasing $[H^+]$ and decreasing pH Since E^o for $2Cl^-_{(aq)} \rightarrow Cl_{2(g)} + 2e^-$ is similar to H_2O oxidation, Cl_2 forms	1 1 1	Accept; if $[Cl^-]$ is high, Cl_2 will form $2Cl^-_{(aq)} \rightarrow Cl_{2(g)} + 2e^-$
6c	$Ni_{(s)} \rightarrow Ni^{2+}_{(aq)} + 2e$- **Any one of the following:** • Replenish Ni^{2+} • Maintain Ni^{2+} • Maintains ions in solution • Reduces required pd required to run the cell • Removes the possibility to Cl_2 being produced	1 1	
6d	Corrosion is occurring to the iron $Fe_{(s)} \rightarrow Fe^{2+}_{(aq)} + 2e^-$ (or $Fe_{(s)} \rightarrow Fe^{3+}_{(aq)} + 3e^-$) $O_{2(g)} + 2H_2O_{(l)} + 4e^- \rightarrow 4OH^-_{(aq)}$ Accelerated corrosion since Fe is a stronger reducer than Ni (or Ni is less reactive), or Ni will not corrode as it forms a noble coating	1 1 1	Accept related argument regarding corrosion occurring to the iron ½ mark for only one equation Accept related argument around accelerated corrosion occurs at greatest oxygen concentration difference. ½ mark for indication that Fe (strong reducer) corrodes preferentially.

PART 2 - CRITERION 6

General Comments

Question 7

- Many students lost marks for incorrect units in question 7(a). Failure to include a time unit or using mol rather than mol/L.

- A common mistake in question 7(c) was to simply restate the content of the question as an answer, rather than explaining *why* the catalyst had no effect on ΔH. Reference to what ΔH is a measure of was absent in most answers.

Question	Answer	Marks	Comments / considerations for 2020 exam
7a	$\Delta[H_2O_2] = 1.000 - 0.932 = 0.068$ mol/L $\Delta[O_2] = \Delta[H_2O_2]/2 = 0.068/2 = 0.034$ $\Delta[O_2] = 0.034$ mol/L/day	½ 1 ½	Maximum of 1 mark was awarded to students who did not use the mole ratio to find rate of production of oxygen. Students were deducted ½ mark for no units or inappropriate units. Any unit measuring change in concentration per unit time was acceptable (e.g. mol/L/day, mol/L/hr, mol/L/min, mol/L/s).
7b (i)	The solution should temporarily turn orange/brown due to the production of $Br_{2(aq)}$, and then return to clear.	1 ½	If colour change was mentioned, but not specified (i.e. $Br_{2(aq)}$ is orange/brown), ½ mark was awarded.
7b (ii)	HBr is acting as a catalyst, because… Hydrogen peroxide decomposes at a faster rate in the presence of HBr, and; HBr is not consumed in the reaction – it is regenerated (see Steps 1 and 2).	1 ½ ½	Maximum of 1 mark was awarded for simply identifying HBr as a catalyst. Full marks were awarded for providing TWO pieces of supporting evidence relating to the information provided in the question.
7c	The heat of reaction (ΔH) is dependent on the energy stored in the reactants and the products ($\Delta H = E_{products} - E_{reactants}$). Since a catalyst (HBr in this case) only changes the reaction pathway and does not change the energy content of the reactants or products, it will have no effect on ΔH.	1 1	Variations of this answer including references to Hess' Law or the inclusion of potential energy diagrams were also awarded full marks.

Question 8

- A common error in question 8(d) was a failure to recognise that the ratio required in the question was the reciprocal of that expressed in the K_c expression. This led to many students only receiving 1 mark for the question.
- In question 8(e) many students simply referenced their answer to part d without referring to the effect of additional OH^- on the position of equilibrium and how that shift affected the ratio in question.

Question	Answer	Marks	Comments/considerations for 2020 exam
8a	Straight line with a negative slope.	1	No half marks were awarded for this question.
8b	According to the graph, an increase in temperature causes and increase in $[NH_{3(aq)}]$ (or a decrease in $[NH_4^+{}_{(aq)}]$)… Which means an increase in temperature favours the reverse reaction. According to L.C.P. an increase in temperature will favour the endothermic reaction… Reverse reaction must be endothermic meaning the forward reaction is exothermic.	½ ½ ½ ½	In order to receive full marks, reference to the graph was required as well as reference to Le Chatelier's Principle.
8c	$[H^+] = 10^{-pH} = 10^{-8.22} = 6.026 \times 10^{-9}$ $[OH^-] = Kw/[H^+] = 1.00 \times 10^{-14}/6.026 \times 10^{-9} = 1.66 \times 10^{-6}$ mol L^{-1}	1 1 -½	Students were not required to formally state that 1.66×10^{-6} mol $L^{-1} \approx 1.7\times10^{-6}$ Deduction of ½ mark for missing or incorrect units.
8d	$\frac{[NH_4^+]}{[NH_3]} = \frac{K_w}{[OH^-]} = \frac{1.76 \times 10^{-5}}{1.66 \times 10^{-6}} = 10.6$ $\frac{[NH_3]}{[NH_4^+]} = \frac{1}{10.6} = 0.094$	1 1	Answers left in the form of the reciprocal ratio were awarded 1 mark. It was not necessary to provide and answer of 0.094 to receive full marks. Any ratio written with $[NH_3]$ as the antecedent and $[NH_4^+]$ as the consequent was considered acceptable.
8e	As the pH increases, the ratio **increases.** An increase in pH is due to an increase in $[OH^-]$. According to L.C.P. this will favour the reverse reaction. The reverse reaction will result in an increase in $[NH_3]$ and a decrease in $[NH_4^+]$, causing the ratio to increase.	1 1 1	Students who stated that an increase in pH is due to an increase in $[OH^-]$, but did not reference L.C.P. or the position of equilibrium received ½ mark. Marks were not awarded to statements who relating increased pH to a decrease in $[H^+]$.

Question 9

- A common error in question 9(a) was a failure to represent H^+ and NO_2^- as ions.
- Question 9(c) was not well understood by the majority of candidates. Although students recognised the diprotic nature H_2SO_4 was the reason for its higher ΔH value, many incorrectly stated that its dissociation is an exothermic process. Few candidates mentioned the neutralisation reaction between the acids in question and sodium hydroxide.

Question	Answer	Marks	Comments/considerations for 2020 exam
9a	Examples of correct answers include: • $HNO_{2(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + NO_2^-{}_{(aq)}$ • $HNO_{2(aq)} \rightleftharpoons H^+_{(aq)} + NO_2^-{}_{(aq)}$ • $HNO_{2(aq)} + NaOH_{(aq)} \rightarrow NaNO_{2(aq)} + H_2O_{(l)}$	1	Full marks were only awarded to **balanced, chemically correct** answers. There were no half marks awarded in this question.
9b	A Brønsted-Lowry acid is a proton donor. In this equation, H_2SO_4 is donating a proton and behaving as an acid. A Brønsted-Lowry base is a proton acceptor. In this equation, HNO_3 is receiving a proton and behaving as a base.	½ ½ ½ ½	
9c	The reaction between $H^+_{(aq)}$ from the acid and the $OH^-_{(aq)}$ from sodium hydroxide is exothermic. Since HCl, HNO_3 and H_2SO_4 are all strong acids, the reason for the difference in their respective ΔH values (-58 kJ, -58 kJ and -115 kJ) is that HCl and HNO_3 are monoprotic, while H_2SO_4 is diprotic, meaning H_2SO_4 produces twice the number of $H^+_{(aq)}$, hence the ΔH value for its reaction with NaOH is roughly twice that of HCl and HNO_3. HNO_2 is a weaker acid than HCl and HNO_3, so it is only partially dissociated so some energy is used to break the bonds between the ions (H^+ and NO_2^-), hence it has a lower ΔH (-56 kJ vs -58 kJ).	1 1 1	In order to gain marks in this question, students needed to refer to the exothermic nature of the reaction between the acids in the table and the sodium hydroxide. Reference to the diprotic nature of the H_2SO_4 was only awarded marks if it was in the context of its reaction with NaOH.

Question 10

- A common error in question 10(a) was misrepresenting E_a as the difference between the products and the maximum E_P value.

- Many students misinterpreted question 9(c) and also included the curve for the change of concentration of $Y_{(g)}$. This was not required in the question and no marks were awarded or deducted for its inclusion.

Question	Answer	Marks	Comments/considerations for 2020 exam
10a	Correct shape of curve (endothermic). Fully labelled graph including E_a, ΔH, reactants ($G_{(g)}$) and products ($X_{(g)}$, $Y_{(g)}$).	1 1	No marks awarded to exothermic shape -½ mark per error, to a maximum of 1 mark. NOTE: students were expected to label the actual species present ($G_{(g)}$, $X_{(g)}$, $Y_{(g)}$). Marks were not awarded for simply labelling as "reactants" and "products".
10b	Initially the forward reaction is favoured and its rate is highest because there is the highest concentration of $G_{(g)}$ and hence its rate of decompositions is fastest. As the reaction proceeds, the concentration of $G_{(g)}$ decreases and the concentration of the products, $X_{(g)}$ and $Y_{(g)}$, increases decreasing the rate of the forward reaction and increasing the rate of the reverse reaction. (This is evident from the shape of the curve.) Eventually (at roughly 10 minutes) the rate of the reverse reaction is equal to the rate of the forward reaction and equilibrium has been reached.	1 1 1	Reference to the increase in concentration of the products ($X_{(g)}$ and $Y_{(g)}$) at some stage during the answer was required for full marks.
10c	As volume is halved, concentration of all reactants increases (is doubled). According to L.C.P., the reverse reaction is favoured causing a partial decrease in pressure of the products ($X_{(g)}$ and $Y_{(g)}$) and increase in pressure of $G_{(g)}$. Graph needs to show a rapid increase in both gases, followed by a subsequent decrease in $X_{(g)}$ and an increase in $G_{(g)}$, at a labelled ratio of 2:1.	1 2	-½ mark if students failed to mention the doubling of concentration/pressure in response to halving of volume (this could be stated either in their explanation or graphically). -½ mark if students did not include the 2:1 ratio of change in $[X_{(g)}]$ vs change in $[G_{(g)}]$.

Question 11

- In question 11(a), many students simply stated that the "forward reaction" or "increased temperature" would favour the production of $H_{2(g)}$, rather than referencing either of the driving forces (i.e. minimum enthalpy, maximum entropy) as requested in the question.
- In question 11(b), a common incorrect answer was that carbon is omitted from the K_c expression because it has a concentration of zero.
- Most candidates enjoyed success in question 11(d), with the most common errors being a failure to factor in the volume of 2.00 L to calculate equilibrium concentration, and/or assuming that the amount of steam present at equilibrium was the same as that present initially (0.200 mol).

Question	Answer	Marks	Comments/considerations for 2020 exam
11a	Maximum entropy will favour the forward reaction which favours the production of $H_{2(g)}$. There is greater disorder on the products side of the reaction (2 moles of gas) vs the reactants side (1 mole of gas), OR; The reverse reaction is exothermic, hence is favoured by a decrease in enthalpy, and since it is an equilibrium system, forward reaction must be favoured by an increase in entropy.	1 1	
11b	Carbon is a solid. As a solid, its concentration is constant.	½ ½	
11c (i)	$Q = \frac{[H_{2(g)}][CO_{(g)}]}{[H_2O_{(g)}]} = \frac{0.0594 \times 1.25}{0.285} = 0.261$ Since $Q \neq K_c$, system is not at equilibrium	1 1	1 mark for correct calculation of Q.
11c (ii)	Reverse/backward/left	1	No half-marks awarded for this question. It was possible to get full marks for an error carried forward from part (i).
11d	Completion of I.C.E. diagram or some other means of correctly finding the number of moles of all species present at equilibrium. Factoring in the volume of 2.00 L to correctly calculate the concentration of all species at equilibrium. Substitution of equilibrium concentration values into K_c expression and successful calculation of K_c.	1 1 1	Full marks were awarded for correct answer of K_c = 0.158 (no units expected). Two marks were awarded for answers where students used number of moles rather than concentration in K_c expression, giving an answer of K_c = 0.317 (-½ mark for obvious calculation error.)

PART 3 - CRITERION 7

General Comments

Students were better able to answer the organic questions rather than the atomic structure and gas questions.

Question 12

There was some confusion between the terms "orbital", "sub-shell" and "shell".

Question	Answer	Marks	Comments/considerations for 2020 exam
12a	Principal quantum number **OR** e^- shell number **OR** 2nd energy level Number of e^- in '*p*' orbital/subshell	½ ½	No deductions if '*p*' is missing
12b (i)	B, C, D, A	1	½ mark if two letters are in correct position
12b (ii)	First e^- is least attracted to nucleus Fewest protons out B, C and D but same no. of shells Full outer shell/noble gas configuration e^- are close to nucleus	½ ½ ½ ½	½ mark if order is back-to-front
12c	B 3 valence e^-s Large increase between 3rd and 4th IEs indicates e^- is removed from a full shell	½ ½ 1	½ mark for noticing the increase in IE without any further detail

Question 13

Note that this question is about ions, not atoms.

Question	Answer	Marks	Comments/considerations for 2020 exam
13a	$1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$	1	Full mark given for [Ne] $3s^2\ 3p^6$ ½ mark given for [Ar] ½ mark for correct configurations of atoms instead of ions -½ mark for minor error
13b	Ca^{2+} , K^+ , Cl^- Number of e^-s are the same Number of protons are different Describe link between attraction and size of ion	1 ½ ½ 1	-½ mark if charges aren't included with element symbols

Question 14

Question	Answer	Marks	Comments/considerations for 2020 exam
14a	Krypton **OR** Radon Atom has large radius, valence e^- are less strongly attracted to nucleus and can therefore form covalent bonds	1 1	½ mark if "same valence e^-s therefore similar reactions" argument is used
14b	Highly electronegative elements strongly attract e^- Xe has a stable e^- configuration Valence e^- can be partially removed to form covalent bonds	1 ½ ½	

Question 15

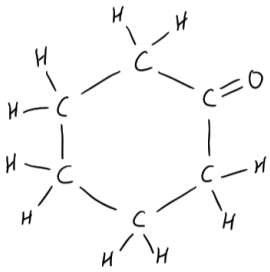
This was a challenging question. Common misconceptions include:

- "The gradient of both lines are equal" (the gradient of the H_2 line would technically be half the gradient of the N_2 line)
- "H_2 would have higher E_k because it has a lower mass" (H_2 would have a higher *velocity*. E_k determines pressure, not the velocity)

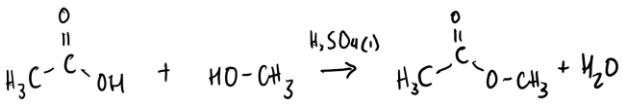
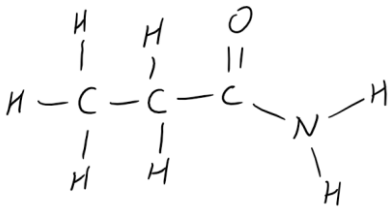
Question	Answer	Marks	Comments/considerations for 2020 exam
15a	Molecules move freely at 0°C Collide with walls of container	1 1	
15b	Straight line intercepts P axis at half the height of other line Straight line – when extrapolated – intercepts T axis at -273°C	½ ½	
15c	Half the number of molecules = Half the pressure Line should intercept at (-273, 0)	2 1	1 mark for identifying fewer molecules = less pressure 1 mark for quantifying the pressure

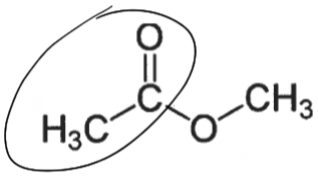
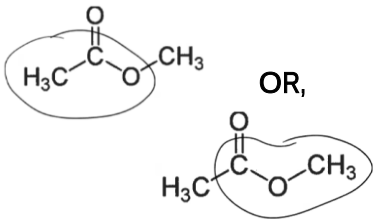
Question 16

A significant number of students assumed that boiling involved breaking *intra*molecular bonds, not the intermolecular bonds.

Question	Answer	Marks	Comments/considerations for 2020 exam
16a	$H_2SO_{4\,(l)}$ **OR** $H_3PO_{4\,(l)}$ $HCl_{(g)}$	½ ½	No states required
16b	cyclohexanol	1	-½ mark for each error -½ mark for 'cyclic' No deductions for cyclohexan-1-ol
16c	R, P, Q Reasons reflect order of compounds (name IMFs, relate strength of IMF with boiling point)	1 each	-½ mark for omitting each IMF name
16d (i)		1	Semi-structural formula accepted No marks for any other structure
16 d(ii)	Drawn-in line reflects compound drawn in part (i) Presence/absence of OH peak Presence/absence of C=O peak	1 1	No mark given if OH group is drawn in (i) and student did not draw line showing OH peak in (ii) -½ mark if peak position was incorrect

Question 17

Question	Answer	Marks	Comments/considerations for 2020 exam
17a	Methyl ethanoate	1	No marks given if error/s in answer
17b (i)	$Na_{(s)}$ **OR** $Na_2CO_{3\,(s)}$	1	Li, Na or K accepted Any carbonate salt accepted (e.g. $CaCO_3$) -½ mark for not specifying the active metal 0 marks if reagent produces an unobservable reaction (e.g. $NaOH_{(aq)}$) If answer involves pH, ½ mark if example of pH indicator is given 0 marks if example of pH indicator is not specified
17b (ii)	Adding reagent to Compound K would produce a gas (observe bubbles) Adding reagent to Compound J would produce no reaction	1 1	If answer involves pH, 1 mark is given only if explanation is well supported
17b (iii)	$2CH_3CH_2COOH_{(aq)} + 2Na_{(s)} \rightarrow 2CH_3CH_2COO^-Na^+_{(aq)} + H_{2\,(g)}$ **OR,** $2CH_3CH_2COOH_{(aq)} + Na_2CO_{3\,(s)} \rightarrow 2CH_3CH_2COO^-Na^+_{(aq)} + H_2O_{(l)} + CO_{2\,(g)}$	1	Equation must match the reagent given in (i)
17c		2	-½ mark if no H_2SO_4 -½ mark if no H_2O -½ mark for each error
17d	The unreacted reactants are soluble in water Compound J is not soluble in water	1 1	
17e		1	Semi-structural formula was accepted
17f (i)	Peak represents the ionised molecule of J **OR** Molecular mass of J	1	

17f (ii)	Molecular mass of J 	1	½ mark: 

PART 4 - CRITERION 8

General Comments

(a) No final units = - ½

(b) Significant figures only penalised in question 22 a) in 2020

(c) Errors were carried forward between question parts and within question parts.

(d) Reminder: Candidate instructions 7. Show your workings in answers to numerical questions. Part marks were allocated accordingly.

(e) Clear thought processes need to be demonstrated in each answer. E.g. working down the page or in two columns. Marks were not deducted for this; however, marks may have been missed through miscommunication of answers.

(f) Show that questions are a guide the expected answer but working/reasoning to support this is required. There was an overreliance of students using the 'show that' value without justification. Examiners were not tricked by correct expected values with incorrect working.

Question 18

(a) Students did not effectively express the reasoning between 1:1 ratio of CO_2:H_2O molecules with the 1:2 ratio of C:H atoms.

(b) Ratio between empirical formula and molecular formula was not expressed as required.

Question	Answer	Marks	Comments/considerations for 2020 exam
18a	$n(CO_2) = 1.32/44.01 = 0.0299$ ∴ $n(C) = 0.0299$ $n(H_2O) = 0.540/18.016 = 0.0299$ ∴ $n(H) = 2 \times 0.0299 = 0.0599$ mol Ratio C:H = 0.0299 : 0.0599 or 1:2 ∴ CH_2 = C_nH_{2n} = alkene	½ ½ 1	If answer is inverted/reversed (eg 2:1) deduct ½ mark
18b	PV = nRT 101.3 x 0.266 = n x 8.31 x 273 n = (101.3 x 0.266)/(8.31 x 273) n = 0.0119 mol M = m/n = 0.500/0.0119 = 42.1 g/mol ∴ C_3H_6 (or name or structure)	1 1 1	(½ if temperature converted correctly) Accept V = 0.266/22.4 = 0.0119 Accept use of formula PV = (m/M)RT

Question 19

(a) Generally well done. Chemistry was sound; however, many algebraic manipulation errors were made.

(b) Surprisingly this was misinterpreted as an E=mcΔT question.

Common error of calculating M(H) rather than M(H_2).

(c) Some students treated this as a strong acid rather than a weak acid.

Generally well done.

Question	Answer	Marks	Comments/considerations for 2020 exam
19a	**Bond Breaking** 3 x N-H = 3 x 391 = 1173 4 x C-H = 4 x 413 = 1652 = +2825 **Bond Forming** 1 x C-H = 413 1 x C≡N = X 3 x H-H = 3 x 432 = 1296 = -(1709 + x) ΔH = $E_{breaking}$ + $E_{forming}$ +251 = 2852 – (1709 + x) X = -865 kJ/mol	2 1	Accept algebraic method to obtain answer for 3 marks
19b	$n(H_2)$ = m/M = 1320/2.016 = 655 mol E = n x ΔH = 655 x (251/3) = 5.48 x 10^4 kJ	1 1	Deduct ½ mark if not divided by 3. Accept MJ or J
19c	n(HCN) = m/M = 5.00/27.03 = 0.185 mol c(HCN) = n/V = 0.185/0.250 = 0.740 mol/L Let x = [H^+] I: HCN 0.740, H^+ 0, CN^- 0 C: HCN -x, H^+ +x, CN^- +x E: HCN 0.740 - x, H^+ x, CN^- x Ka = [H+][CN-]/[HCN] 4.9 x 10^{-10} = x.x/(0.740 – x)* x2 = 4.9 x 10^{-10} x 0.740 x = 1.90 x 10-5 mol/L pH = -log(1.9 x 10^{-5}) = 4.72	1 1 ½ ½ 1	No mark assigned to ICE diagram Must include Ka expression Must include assumption (any format accepted) ECF accepted within question

* Note: (0.740 – x) = 0.740 since x ≪ 0.740

Question 20

(a) Students did not effectively express the reasoning between the 1:2 ratio of reagents and the identification of the limiting reagent.

(b) Students did not recognise the m in E=mcΔT is the mass of the acid (50 g).

Students showed working that did not equal their stated answer (attempting to make it fit the 'show that').

(c) Done well when identified as a Hess' Law question; however, some students did not pick this up.

Question	Answer	Marks	Comments/considerations for 2020 exam
20a	$n(Na_2CO_3)_{given}$ = 0.0300 mol $n(HCl)_{given}$ = cv = 2.10 x 0.050 = 0.105 mol $n(HCl)_{needed}$ = 2 x $n(Na_2CO_3)$ = 2 x 0.0300 = 0.0600 mol As $n(HCl)_{given}$ > $n(HCl)_{needed}$, HCl is InXs and Na_2CO_3 is limiting	1 ½ ½	Accept variation is calculating LR ratio Statement (or some format) explaining LR need.
20b	E = mcΔT = 50 x 4.184 x 4.9 = 1025 J ΔH = 1.025/0.0300 = 34 kJ/mol ΔH = -34 kJ/mol (since exothermic)	1 1 1	- ½ for incorrect mass of water. - ½ mark for wrong units (not kJ), - ½ for not using LR.
20c	(2 x Equation 2) + (1 x Equation 1) ΔH = +48.4 + +34 = +82.6 kJ	1 1	- ½ mark for one error 83.4 kJ if using estimate from b. No deduction for + or - ΔH

Question 21

(a) Student who used the two step approach had minimal errors compared to students using the combined gas law equation.

When using the combined gas law, students swapped V_1 and V_2 values giving 2.8 L.

(b) This was a demanding question with very few students gaining marks.

Students did not recognise this was a limiting regent question.

Question	Answer	Marks	Comments/considerations for 2020 exam
21a	$P_1V_1/T_1 = P_2V_2/T_2$ (106 x 3)/293 = (101.3 x V2)/298 V = 3.19 L **OR,** n = PV/TR = 106 x 3/(8.31 x 293) = 0.1306 V = n x 24.5 = 0.1306 x 24.5 = 3.20 L	1 1 1 1	- ½ for wrong temp. -1 mark for swapping V_2 and 3 L - ½ for wrong SLC - ½ for wrong temp.

21b	n(X) = 3.00/24.5 = 0.1224 mol n(Y) = 0.1306 mol X is LR n(Z) = n(X) = 0.1224 mol ∴ V(Z) = 3.00 L n(Y)excess = 0.1306 – (0.1224/2) = 0.0694 mol V(Y) = 0.694 x 24.5 = 1.70 L V(total) = 3.00 + 1.70 = 4.70 L	 1 ½ 1 ½	

Question 22

(a) Students recognised the 1:2 ratio in this question; however, they regularly multiplied by 2 rather than dividing by 2. Unfortunately, students attempted to correct their answers to fit 0.07 mol/L without showing any reasoning.

Question	Answer	Marks	Comments/considerations for 2020 exam
22a	$n(HCl) = C \times V = 0.188 \times 0.01968 = 3.699 \times 10^{-3}$ mol = $n(H^+)$ $n(OH^-) = n(H^+)$ $n(Ba(OH)_2) = n(OH^-)/2 = 3.699 \times 10^{-3} / 2 = 1.85 \times 10^{-3}$ mol $c(Ba(OH)_2) = 1.85 \times 10^{-3} / 0.025 = 0.0740$ mol/L Correct significant Figures	1 1 1 1	
22b	$n(Ba(OH)_2)_{aliquot} = 1.85 \times 10^{-3}$ mol $n(Ba(OH)_2)_{250mL} = 1.85 \times 10^{-2}$ mol $m(Ba(OH)_2) = 1.85 \times 10^{-2} \times 171.016 = 3.164$ g $m(H_2O) = 5.836 - 3.164 = 2.672$ g $n(H_2O) = 2.672/18.016 = 0.1483$ mol Ratios $\underline{n(Ba(OH)_2)}$ $\underline{n(H_2O)}$ $1.85 \times 10^{-2}/1.85 \times 10^{-2}$ $0.1483/1.85 \times 10^{-2}$ 1 8 ∴ $Ba(OH)_2.8H_2O$ Alternate method accepted M = m/n = 5.836/0.0185 = 315 g/mol $M(Ba(OH)_2.xH_2O) = 315$ ∴ x = 8	½ ½ ½ ½ ½ ½	Accept 3.164 g = 1 mark. Alternate methods accepted. If using 0.07, obtain 1:9 = accepted

Question 23

Generally well done; however, many students didn't get to this question. Those who did, gained the majority of marks.

(a) It was clear students struggled with the duel ratios in this question. It was possible to gain the correct answer by not understanding the ratios, and marks were lost for this.

Question	Answer	Marks	Comments/considerations for 2020 exam
23a	$n(AgCl) = m/M = 0.706/143.35 = 4.93 \times 10^{-3}$ mol (or = n(Ag+)) $m(Ag) = 4.93 \times 10^{-3} \times 107.9 = 0.531$ g Alternative methods – Percentage approach %Ag in AgCl = 107.9/143.35 = 75.37 % M(Ag) = 0.706 x 0.7527 = 0.531 g	1 1 1 1	Accept one step solutions for 2 marks Accept one step solution for 2 marks
23b	$n(S_2O_3^{2-}) = cV = 0.105 \times 0.03752 = 3.94 \times 10^{-3}$ mol $n(I_2) = ½ \times 3.94 \times 10^{-3} = 1.97 \times 10^{-3}$ mol $n(Cu^{2+}) = 2 \times 1.97 \times 10^{-3} = 3.94 \times 10^{-3}$ mol $m(Cu) = nM = 3.94 \times 10^{-3} \times 63.54 = 0.250$ g ∴ m(Ag + Cu) = 0.531 + 0.250 = 0.782 g	½ ½ ½ ½ 1	Must show steps in working due to mole ratios cancelling
23c	M(Au) = 1.25 -0.782 = 0.468 g ∴ %Au = 0.468/1.25 = 37.5 %	1 1	If using 0.8 answer is 36% accepted