Advanced GCE Chemistry A

Unit F325 Equilibria, Energetics and Elements – Medium banded Candidate Style Answer

Introduction

OCR has produced these candidate style answers to support teachers in interpreting the assessment criteria for the new GCE specifications and to bridge the gap between new specification release and availability of exemplar candidate work.

This content has been produced by senior OCR examiners, with the input of Chairs of Examiners, to illustrate how the sample assessment questions might be answered and provide some commentary on what factors contribute to an overall grading. The candidate style answers are not written in a way that is intended to replicate student work but to demonstrate what a “medium” or “high” response might include, supported by examiner commentary and conclusions.

As these responses have not been through full moderation and do not replicate student work, they have not been graded and are instead, banded “medium” or “high” to give an indication of the level of each response.

Please note that this resource is provided for advice and guidance only and does not in any way constitute an indication of grade boundaries or endorsed answers.

1 **One cause of low-level smog is the reaction of ozone, O_3, with ethane, C_2H_4. The smog contains methanal, HCHO(g).**

The equation for methanal production is shown below as equation 1.1.

$O_3(g) + C_2H_4(g) \longrightarrow 2HCHO(g) + \frac{1}{2} O_2(g)$ **e**

(a) **The rate of the reaction was investigated, using a series of different concentrations of either $C_2H_4(g)$ or $O_3(g)$, by measuring the initial rate of formation of HCHO(g).**

The results are shown below.

experiment	**$[O_3(g)]$ / 10^{-7} mol dm^{-3}**	**$[C_2H_4(g)]$ / 10^{-8} mol dm^{-3}**	**initial rate / 10^{-12} mol dm^{-3} s^{-1}**
1	0.5	1.0	1.0
2	2.0	1.0	4.0
3	4.0	2.0	16.0

(i) **Analyse and interpret the results to deduce the order of reaction of each reactant and the rate equation.**

Explain your reasoning.

[5]

Candidate style answer	*Examiner's commentary*
Experiment 2 has 4 times the concentration of O_3 as Experiment 1 and the rate increases by 4. So the order is 1 with respect to O_3 Experiment 3 has double the concentration of C_2H_4 and O_3 as Experiment 2 and the rate has quadrupled. O_3 is first order anyway so C_2H_4 must also be first order So the rate equation is: rate = k $[O_3]$ $[C_2H_4]$	

(ii) **Calculate the value of the rate constant and state the units.**

[3]

Candidate style answer	*Examiner's commentary*
rate = k $[O_3]$ $[C_2H_4]$ so $k = \frac{rate}{[O_3][C_2H_4]}$ $= k = \frac{1.0 \times 10^{-12}}{(0.5 \times 10^{-7}) \times (1.0 \times 10^{-8})} = 2 \times 10^{-13}$ units = mol dm^{-3} s^{-1} rate constant = 2×10^{-13} units = mol dm^{-3} s^{-1}	Two mistakes. The candidate has not worked out the value of k accurately. The candidate has multiplied by 1.0 x 10^{-8} instead of dividing. The candidate would be advised to improve their calculator skills for complex expressions. The units are incorrect. Many candidates try to memorise these for different orders but it is safer to work them out from first principles: units = $k = \frac{mol\ dm^{-3} s^{-1}}{(mol\ dm^{-3}) \times (mol\ dm^{-3})}$ = dm^{3} mol^{-1} s^{-1}

	The correct answer for k is 2.0 x 103 dm3 mol–1 s–1

(iii) **Using equation 1.1, deduce the initial rate of formation of $O_2(g)$ in experiment 1.**

Explain your reasoning.

Candidate style answer	*Examiner's commentary*
The same as the other rate. answer = 1.0×10^{-12} mol dm^{-3} s^{-1}	The candidate has not considered the equation 1.1 at all and there is no explanation. 2 mol O_3 form 0.5 moles O_2 Therefore rate of formation of O_2 = one quarter rate of disappearance of O_3. The correct answer is 2.5×10^{-3} mol dm^{-3} s^{-1}

(iv) **The experiment was repeated at a higher temperature.**

How would the new conditions affect the rate of the reaction and the value of the rate constant?

[1]

Candidate style answer	*Examiner's commentary*
The rate increases so k must also increase	

(b) Nitrogen monoxide, NO, is involved in formation of ozone at low levels.

Nitrogen monoxide is produced by combustion in car engines. Ozone is then formed following the series of reactions shown below.

$$NO(g) + \tfrac{1}{2}O_2(g) \longrightarrow NO_2(g)$$
$$NO_2(g) \longrightarrow NO(g) + O(g)$$
$$O_2(g) + O(g) \longrightarrow O_3(g)$$

Write the overall equation for this reaction sequence.
Identify the catalyst and justify your answer.

[3]

Candidate style answer	*Examiner's commentary*
The overall equation is $O_2(g) + \tfrac{1}{2}O_2(g) \longrightarrow O_3(g)$ The catalyst is NO because it isn't in the overall equation.	Although NO has been correctly identified as the catalyst, many molecules do not feature in the overall equation! The explanation must consider the two steps with NO being used up in the first step but regenerated in the second step.

[Total: 13]

2 Phenol, C_6H_5OH, is a powerful disinfectant and antiseptic.

Phenol is a weak Brønsted–Lowry acid.

$$C_6H_5OH(aq) \rightleftharpoons H^+(aq) + C_6H_5O^-(aq) \quad K_a = 1.3 \times 10^{-10}\ \text{mol dm}^{-3}$$

(a) Define the following terms:

(i) A *Brønsted–Lowry* acid,

[1]

Candidate style answer	*Examiner's commentary*
H^+ donor	

(ii) A *weak* acid.

[1]

Candidate style answer	*Examiner's commentary*
Partially dissociates	Responses to **(a)** are short but to the point.

(b) When phenol is mixed with aqueous sodium hydroxide, an acid–base reaction takes place.

$$C_6H_5OH(aq) + OH^-(aq) \rightleftharpoons C_6H_5O^-(aq) + H_2O(l)$$

In the available spaces,
label one conjugate acid–base pair as acid 1 and base 1,
label the other conjugate acid–base pair as acid 2 and base 2.

[1]

Candidate style answer	*Examiner's commentary*
$C_6H_5OH(aq) + OH^-(aq) \rightleftharpoons C_6H_5O^-(aq) + H_2O(l)$ acid 1 base 1 base 2 acid 2	The acids and bases are not paired correctly. The components in an acid-base pair differ by H^+ with each on opposite sides of the equilibrium.

(c) A solution of phenol in water has a concentration of 4.7 g dm^{-3}.

(i) Write an expression for the acid dissociation constant, K_a, of phenol.

[1]

Candidate style answer	*Examiner's commentary*
$K_a = \frac{[H^+(aq)]\,[C_6H_5O^-(aq)]}{[C_6H_5OH(aq)]}$	

(ii) Calculate the pH of this solution of phenol.

[5]

Candidate style answer	*Examiner's commentary*
$1.3 \times 10^{-10} \approx \frac{[H^+(aq)]^2}{4.7}$ mol dm^{-3} $[H^+] = \sqrt{1.3 \times 10^{-10} \times 4.7} = 2.47 \times 10^{-5}$ mol dm^{-3} $pH = -\log[H^+] = -\log 2.47 \times 10^{-5} = 4.61$	The candidate has not worked out the molar concentration of phenol and has incorrectly used the concentration in g dm^{-3}. The missing steps are: M_r C_6H_5OH = 94 $[C_6H_5OH(aq)] = \frac{4.7}{94} = 0.050$ mol dm^{-3} Despite this error, the method used with the wrong starting concentration is correct and the candidate would have collected all subsequent marks for a good method. The correct answer using the molar concentration of phenol of 0.050 mol dm^{-3} is 5.59.

(d) As part of an investigation, a student needed to prepare a buffer solution with a pH value of 8.71. From the K_a value of phenol, the student thought that a mixture of phenol and sodium phenoxide could be used to prepare this buffer solution.

The student decided to use a 0.200 mol dm^{-3} solution of phenol, mixed with an equal volume of sodium phenoxide.

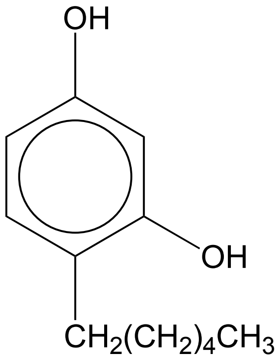
Use your knowledge of buffer solutions to determine the concentration of sodium phenoxide solution that the student would need to mix with the 0.200 mol dm^{-3} phenol solution.

[3]

Candidate style answer	*Examiner's commentary*
$[H^+(aq)] = 10^{-pH} = 10^{-8.71} = 1.99 \times 10^{-9}$ mol dm^{-3} $K_a = \frac{[H^+(aq)]\,[C_6H_5O^-(aq)]}{[C_6H_5OH(aq)]} = \frac{[H^+(aq)]^2}{[C_6H_5OH(aq)]}$ $[C_6H_5OH(aq)] = \frac{[H^+(aq)]^2}{K_a} = \frac{(1.99 \times 10^{-9})^2}{1.3 \times 10^{-10}}$ $= 3.0 \times 10^{-8}$ mol dm^{-3}	This is a very muddled response to a difficult question. The candidate doesn't seem to have understood what was needed and has confused the standard buffer calculation with that for a weak acid (despite having already used the weak acid calculation earlier in the question.). The candidate has tried to work out the concentration of phenol (despite being provided with it) and has ignored the salt altogether. The candidate would have been rewarded for the initial calculation of the $H^+(aq)$ concentration but there is little sense in the remainder of the calculation.

(e) Hexylresorcinol is an antiseptic used in solutions for cleansing wounds and in mouthwashes and throat lozenges.

The structure of hexylresorcinol is shown below.



Identify a chemical that could be added to hexylresorcinol to make a buffer solution. Explain your answer.

[1]

Candidate style answer	*Examiner's commentary*
Add some ethanoic acid and sodium ethanoate	In **(e)**, the candidate has added another buffer solution and has not used the hexylresorcinol.

[Total: 13]

3 ***Syngas*** **is a mixture of carbon monoxide and hydrogen gases, used as a feedstock for the manufacture of methanol.**

A dynamic equilibrium was set up between carbon monoxide, CO, hydrogen, H_2, and methanol, CH_3OH, in a 2.0 dm^3 sealed vessel.
The equilibrium is shown by equilibrium 3.1 below.

$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$ equilibrium 3.1

The number of moles of each component at equilibrium is shown below:

component	**CO(g)**	**H_2(g)**	**CH_3OH(g)**
number of moles at equilibrium	**6.20×10^{-3}**	**4.80×10^{-2}**	**5.20×10^{-5}**

(a) **State two features of a system that is in *dynamic equilibrium*.**

[2]

Candidate style answer	*Examiner's commentary*
1. The rate of forward reaction is the same as the rate of reverse reaction 2. The concentrations of reactants and products are constant	

(i) **Write an expression for K_c for this equilibrium system.**

[1]

Candidate style answer	*Examiner's commentary*
$K_c = \frac{[CH_3OH]}{[CO]\,[H_2]^2}$	

(ii) **Calculate K_c for this equilibrium. State the units.**

[4]

Candidate style answer	*Examiner's commentary*
$K_c = \frac{5.20 \times 10^{-5}}{6.20 \times 10^{-3} \times (4.80 \times 10^{-2})^2} = 3.64$ units: $\frac{mol\ dm^{-3}}{mol\ dm^{-3} \times (mol\ dm^{-3})^2} = dm^6\ mol^{-2}$ $K_c = 587$ units: $dm^6\ mol^{-2}$	The candidate has used the molar values from the table and has not converted these to concentrations in mol dm^{-3}. As the total volume of the container was 2 dm^3, each molar value should have been divided by 2. The candidate has also squared the whole of the denominator in the K_c expression, instead of just the second term, 4.80×10^{-2}. The correct calculated value of K_c is 14.56.

(c) **The pressure was increased whilst keeping the temperature constant. The mixture was left to reach equilibrium.**

The equilibrium position of equilibrium 3.1 shifted to the right.

(i) **Explain why the equilibrium position shifted to the right.**

[1]

Candidate style answer	*Examiner's commentary*
There are less moles on the right hand side	

(ii) **What is the effect, if any, on the value of K_c?**

[1]

Candidate style answer	*Examiner's commentary*
It gets bigger	The response to **(i)** is risky as it is the moles of **gas** that are critical, rather than just 'the number of moles'. Luckily, here, all the species are in the gaseous state. In **(ii)**, K_c only changes with temperature.

(d) **The temperature was increased whilst keeping the pressure constant. The mixture was left to reach equilibrium.**

The value of K_c for equilibrium 3.1 decreased.

(i) **Explain what happened to the equilibrium position in equilibrium 3.1.**

[1]

Candidate style answer	*Examiner's commentary*
The equilibrium position moves to the left hand side	

(ii) **Deduce the sign of the enthalpy change for the forward reaction shown in equilibrium 3.1.**

Explain your reasoning.

[1]

Candidate style answer	*Examiner's commentary*
The enthalpy change is negative	The response here is effectively a 50:50 guess. The question asks for an explanation which should be in terms of a high temperature favouring the endothermic direction

(e) **Methanol can be used as an additive to petrol.**

(i) **Write an equation for the complete combustion of methanol, CH_3OH.**

[1]

Candidate style answer	*Examiner's commentary*
$CH_3OH + 1\frac{1}{2} O_2 \longrightarrow CO_2 + 2H_2O$	

(ii) **Suggest why methanol is added to petrol.**

[1]

Candidate style answer	*Examiner's commentary*
Methanol has got oxygen in it so it adds oxygen to the fuel and makes it burn better.	

[Total: 13]

4 **Table 4.1 shows the enthalpy changes needed to calculate the lattice enthalpy of calcium oxide, CaO.**

Table 4.1

process	**enthalpy change/ kJ mol^{-1}**
first ionisation energy of calcium	+590
second ionisation energy of calcium	+1150
first electron affinity of oxygen	–141
second electron affinity of oxygen	+ 791
enthalpy change of formation of calcium oxide	–635
enthalpy change of atomisation of calcium	+178
enthalpy change of atomisation of oxygen	+248

(a)(i) **Explain why the second ionisation energy of calcium is more endothermic than the first ionisation energy of calcium.**

[2]

Candidate style answer	*Examiner's commentary*
Ca^+ is smaller than a Ca atom	As with question **3(d)**, there is no explanation. The candidate should have also described the consequence of the different sizes in terms of attraction linked to different energy requirements.

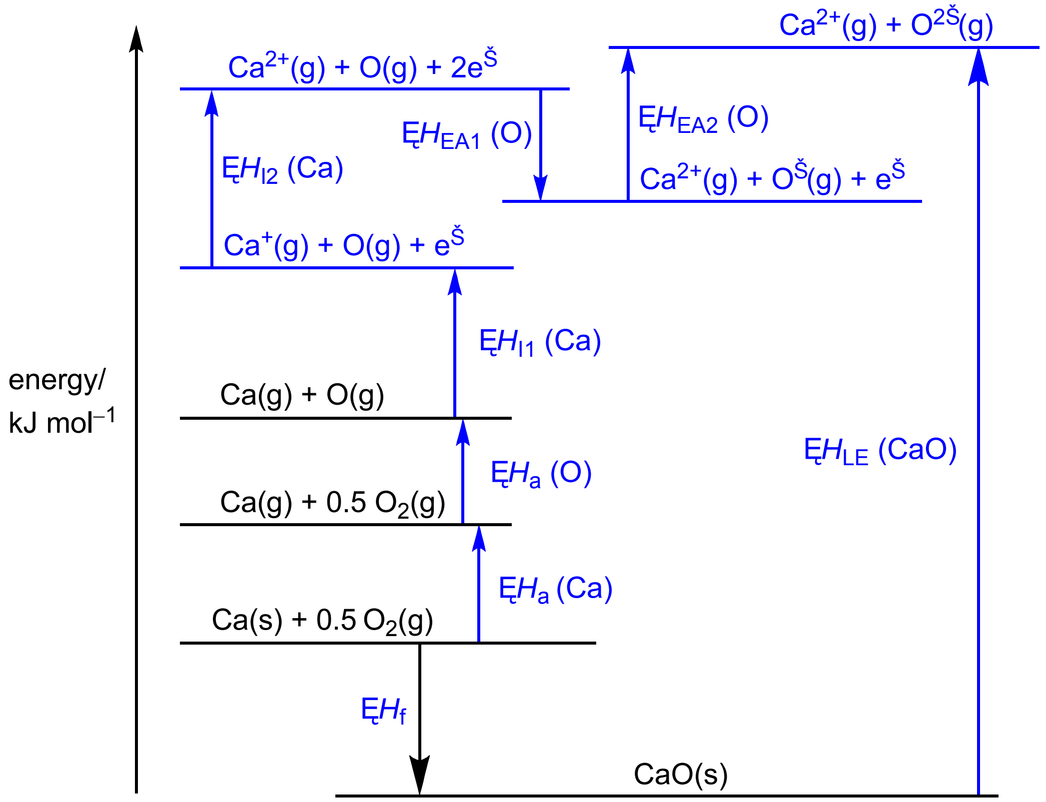
(ii) **Suggest why the second electron affinity of oxygen is positive.**

[2]

Candidate style answer	*Examiner's commentary*
Because energy is needed.	The candidate has not explained why energy is needed to overcome the repulsion between the negative ion and the negative electron.

(b) Complete the Born–Haber cycle for calcium oxide below.

Use the data in Table 4.1 to calculate the lattice enthalpy of calcium oxide.



[5]

Candidate style answer	*Examiner's commentary*
Lattice enthalpy = 178 + 248 + 590 + 1150 + (-141) + 791) -635 = +3451 kJ mol^{-1} lattice enthalpy = +3451 kJ mol^{-1}	Most candidates are adept at constructing Born-Haber cycles. This is a good attempt but unfortunately the lattice enthalpy is the wrong way around in the cycle. This is the only mistake though and the method in sound giving the lattice enthalpy with the wrong sign. The candidate should have spotted this mistake as lattice enthalpies are always negative.

(c) The lattice enthalpies of calcium oxide and magnesium oxide are different.

Comment on this difference.
In your answer you should make clear how the sizes of the lattice enthalpies are related to any supporting evidence.

[3]

Candidate style answer	*Examiner's commentary*
Mg^{2+} is larger than Ca^{2+} so there will be a different attraction for O^{2-}.	Attraction is stated but without qualifying whether the attraction is greater or smaller. There is no discussion at all of lattice enthalpy.

(d) Most metals can be extracted by reduction from compounds obtained from their naturally-occurring ores.

Metals such as calcium and magnesium are normally extracted by electrolysis but it is feasible that calcium oxide could be reduced by carbon as shown in equation 4.1.

$CaO(s) + C(s) \rightarrow Ca(s) + CO(g)$ equation 4.1

Use the data in the table below to help you answer parts (i)–(iii) below.

	CaO(s)	**C(s)**	**Ca(s)**	**CO(g)**
$\Delta H_f^\ominus$/kJ mol^{-1}	**–635**	**0**	**0**	**–110**
$S^\ominus$/J K^{-1} mol^{-1}	**39.7**	**5.7**	**41.4**	**197.6**

(i) Calculate the standard enthalpy change for the CaO reduction in equation 4.1.

[1]

Candidate style answer	*Examiner's commentary*
ΔH = products – reactants $= -110 - (-635) = 525$ kJ mol^{-1} $\Delta H^\ominus =$ kJ mol^{-1}	

(ii) Calculate the standard entropy change for the CaO reduction in equation 4.1.

[1]

Candidate style answer	*Examiner's commentary*
ΔS = products – reactants $= 41.4 + 197.6 - (39.7 + 5.7) = 193.6$ J K^{-1} mol^{-1} $\Delta S^\ominus =$ J K^{-1} mol^{-1}	

(iii) Calculate the minimum temperature at which the carbon reduction in equation 4.1 is feasible.

[5]

Candidate style answer	*Examiner's commentary*
$\Delta G = \Delta H - T\Delta S$ $\therefore T = \Delta H - \Delta S = 525 - 193.6 = 331.4$ K minimum temperature = 331.4 K	The candidate has little idea of how to solve part **(d)(iii)** and there is no statement that ΔG must be negative for a reaction to be feasible. The free energy expression has been correctly shown but the next stage makes little sense. Free energy calculations do follow a set method that can be mastered by practice. The candidate seems to have been poorly prepared for this type of question. Energy is a clear weakness of this candidate. Questions requiring explanations are responded with no explanations. The Born-Haber cycle is known reasonably well but there is little evidence of any understanding of the relationship between enthalpy, entropy and temperature in terms of free energy.

[Total: 19]

5 **Use the standard electrode potentials in the table below to answer the questions that follow.**

I	$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$	$E^\ominus = -0.44$ V
II	$V^{3+}(aq) + e^- \rightleftharpoons V^{2+}(aq)$	$E^\ominus = -0.26$ V
III	$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	$E^\ominus = 0.00$ V
IV	$O_2(g) + 4H^+(aq) + 4e^- \rightleftharpoons 2H_2O(l)$	$E^\ominus = +0.40$ V

(a) **An electrochemical cell was set up based on systems I and II.**

(i) **Write half-equations to show what has been oxidised and what has been reduced in this cell.**

[2]

Candidate style answer	*Examiner's commentary*
oxidation: $Fe \rightarrow Fe^{2+} + 2e^-$ reduction: $V^{3+} + e^- \rightarrow V^{2+}$	

(ii) **Determine the cell potential of this cell.**

[1]

Candidate style answer	*Examiner's commentary*
E_{cell} is the difference so $E_{cell} = 0.26 - (-0.44)$ $= 0.18$ V $E_{cell} = 0.18$ V	

(b) An electrochemical fuel cell was set up based on systems III and IV.

(i) Construct an equation for the spontaneous cell reaction. Show your working.

[2]

Candidate style answer	*Examiner's commentary*
Multiply III to get the electrons the same. The add together $4H^+(aq) + 4e^- \longrightarrow 2H_2$ $O_2(g) + 4H^+(aq) + 4e^- \rightleftharpoons 2H_2O(l)$ *Add to get overall:* $O_2(g) + 8H^+(aq) \rightleftharpoons 2H_2O(l) + 2H_2$	The candidate knows that the electrons have to be balanced but the less positive system has not been reversed and the electrons have subsequently been ignored. Many candidates get into a muddle when trying to obtain an overall cell reaction from electrode potentials. The best technique is to follow logical steps and to practise.

(ii) Fuels cells based on systems such as III and IV are increasingly being used to generate energy.

Discuss two advantages and two disadvantages of using fuels cells for energy rather than using fossil fuels.

[4]

Candidate style answer	*Examiner's commentary*
Advantages: *With a fuel cell, there is no carbon monoxide, just water.* *Disadvantages:* *Hydrogen is an inflammable explosive gas which is dangerous.*	The candidate is partly there but has stated just the more obvious advantages and disadvantages. With 4 marks available, it should have been clear that two advantages and two disadvantages were required. This is not difficult but has to be learnt.

[Total: 9]

6 This question looks at different chemical compounds used in medicine.

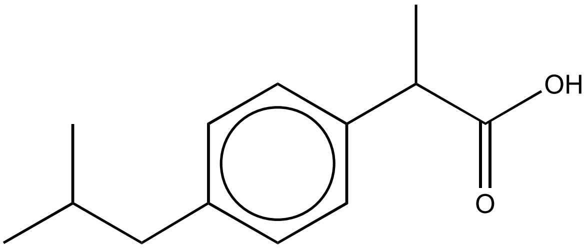
(a) An oxide of nitrogen is used as a general anaesthetic by dentists.
This oxide contains 63.64% N by mass, and has a density of 1.833 g dm^{-3} at room temperature and pressure.

Determine the molecular formula of this gas. Show your working.

[3]

Candidate style answer	*Examiner's commentary*
$N : O = \frac{63.64}{14} : \frac{36.36}{16} = 4.56 : 2.27 = 2 : 1.$ So the formula is N_2O	The candidate has ignored the density, which helps to confirm that the molecular formula is N_2O. The percentages by mass only confirm the empirical formula.

(b) The structure of the painkiller ibuprofen is shown below.



Suggest a chemical that would react with a solution of ibuprofen to produce a gas.

Name the gas produced and write an equation for the reaction.

[2]

Candidate style answer	*Examiner's commentary*
chemical Magnesium gas Hydrogen equation $RCOOH + Mg \longrightarrow RCOOMg + H_2O$	The candidate has simplified down the formula of ibuprofen. This might be fine but is risky. The formula of the magnesium salt is wrong as magnesium ions have the formula Mg^{2+}. The candidate has correctly stated that hydrogen gas would be produced but has inexplicably then produced water instead of hydrogen in the equation. The correct equation using R would be: $2RCOOH + Mg \longrightarrow (RCOO)_2Mg + H_2$

(c) **Lidocaine, $C_{13}H_{20}N_2O_2$, is used as a local anaesthetic in dentistry. Lidocaine is injected by syringe as a solution containing 100 mg in 5.00 cm^3.**

Calculate the concentration, in mol dm^{-3}, of lidocaine in the syringe.

[3]

Candidate style answer	Examiner's commentary
Relative molecular mass = 236 moles lidocaine = $\frac{100}{236} = 0.424$ $n = c \times V$, so $c = \frac{n}{V} = \frac{0.424}{5/1000} = 84.8$ mol dm^{-3} concentration = 84.8 mol dm^{-3}	A sound method but the candidate has not converted mg into g by dividing by 1000. The mistake should have been obvious as such a large concentration is impossible and a patient injected with this dose would be more than anaesthetised! The correct concentration in 1000 times less: 0.848 mol dm^{-3}

(d) **Eugenol is used as a painkiller in dentistry. It is an organic compound of C, H and O.**

A sample of 1.394 g of eugenol was analysed by burning in oxygen to form 3.74 g of CO_2 and 0.918 g of H_2O. Using a mass spectrometer, the molecular ion peak of eugenol was shown to have a *m*/*z* value of 164.

Analyse and interpret this information to determine the molecular formula of eugenol. Show your working clearly.

[5]

Candidate style answer	Examiner's commentary
mass C = $3.74 \times \frac{12}{44} = 1.02$ g mass H = $0.918 \times \frac{2}{18} = 0.102$ g ratio C : H = $\frac{1.02}{12} : \frac{0.102}{1} = 1 : 1.2 = 5 : 6$ C_5H_6 is 66 so the rest must be O. Relative molecular mass is 164 164 - 66 = 98 98/16 = 6 So the molecular formula of eugenol of $C_5H_6O_6$ This adds up to 162 so there must be a mistake in the question.	The candidate has made a good start to the question, successfully working out the ratio of C : H. Unfortunately they have failed to include O in the ratio and have assumed that the C : H ratio of a eugenol molecule is 5 : 6. Had the O been considered, then the candidate would have obtained an empirical formula of C_5H_6O which is doubled to give the correct molecular formula of $C_{10}H_{12}O_2$. The candidate should have suspected that there was something wrong with their method rather than thinking that the question was wrong. The hallmarks of these responses stem from a poor grasp of some of the basics, such as formulae, equations and units.

[Total: 13]

7 This question looks at the chemistry of transition elements.

(a)(i) Explain what is meant by the terms *transition element*, *complex ion* and *ligand*.

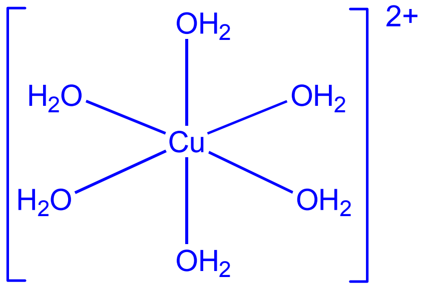
(ii) Discuss, with examples, equations and observations, the typical reactions of transition element ions.

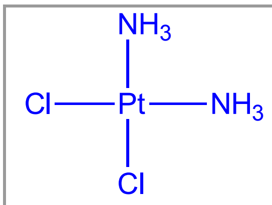
In your answer you should make clear how any observations provide evidence for the type of reaction discussed. [11]

Candidate style answer	*Examiner's commentary*

(b) Describe, using suitable examples and diagrams, the different shapes and stereoisomerism shown by complex ions.

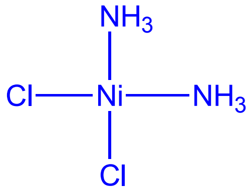
In your answer you should make clear how your diagrams illustrate the type of stereoisomerism involved. [9]

Candidate style answer	*Examiner's commentary*
A transition element has a partly filled d-orbital A complex ion is a metal ion surrounded by ligands A ligand donates a lone pair of electrons Transition metal ions do precipitation. Copper ions form a precipitate with hydroxide. Here is an equation: $Cu^{2+} + 2OH^- \longrightarrow Cu(OH)_2$ It goes blue. Transition metal ions do ligand substitution eg $[Cu(H_2O)_6]^{2+}(aq) + 4NH_3(aq) \longrightarrow$ $[Cu(NH_3)_4(H_2O_2]^{2+}(aq) + 4H_2O\ (l)$ The solution turns into a deep blue colour. The ligands have swapped over. Complex ions can be octahedral, e.g. $[Cu(H_2O_6)]^{2+}$ The bond angles are 90 °.  cis platin is square planar. The bond angle is 90 ° as well.	

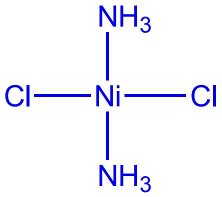


Transition metal complexes can be cis-trans and optical.

$Ni(NH_3)_2Cl_2$ has cis-trans isomerism.



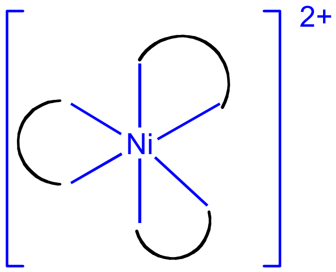
cis

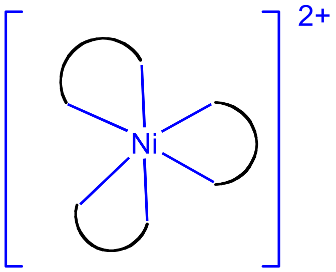


trans

Optical isomers are mirror images of one another.

$[Ni(en)_3]^{2+}$ has optical isomerism. See below.





[Total: 20]

Overall Banding Medium

On the surface, this response looks like a reasonable attempt but important details are missing that often change the meaning of what needs to be communicated.

The transition element definition should have referred to ions of the element and the description of a ligand should have referred to metal ions and the formation of dative covalent bonds.

The description of precipitation lacks detail. ‘It goes blue’ does not help as the solution starts as blue anyway.

Ligand substitution has been learnt well and the equation is correct. The candidate has not described redox reactions at all and this is a serious omission.

Although 2D diagrams may be adequate for square planar complexes. 3D diagrams must be shown for octahedral complexes.

It is insufficient to just state that optical isomers are mirror images – there are non-superimposable. The diagrams of optical isomers would have been sufficient had semicircles been labelled as ‘en’. ‘en’ should have also been introduced as an abbreviation for $H_2NCH_2CH_2NH_2$.

The responses for stereochemistry in **(b)** are of a higher standard than the incomplete responses in **(a)**.

Paper Total: [100]