Advanced GCE Chemistry A

Unit F325 Equilibria, Energetics and Elements – High 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.

$$O_3(g) + C_2H_4(g) \longrightarrow 2HCHO(g) + \tfrac{1}{2}O_2(g)$$ 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* $k = \dfrac{rate}{[O_3]\,[C_2H_4]}$ = $k = \dfrac{1.0 \times 10^{-12}}{(0.5 \times 10^{-7}) \times (1.0 \times 10^{-8})}$ = 2.0×10^{3} *units* = $k = \dfrac{mol\ dm^{-3}\,s^{-1}}{(mol\ dm^{-3}) \times (mol\ dm^{-3})}$ = dm^3 mol^{-1} s^{-1} *rate constant* = 2.0×10^{3} *units* dm^3 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*
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. In experiment 1, rate = $\frac{1.0 \times 10^{Š12}}{4}$ = 2.5 x 10^{-13} answer = 2.5 x 10^{-13} 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.

$$NO(g) + ½O_2(g) \longrightarrow NO_2(g)$$
$$NO_2(g) \longrightarrow NO(g) + O(g)$$
$$O_2(g) + O(g) \longrightarrow O_3(g)$$

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 $O_2(g) + ½O_2(g) \longrightarrow O_3(g)$ The catalyst is NO hasn't been used up.	Excellent responses overall. In **(b)**, the candidate has correctly identified that NO is the catalyst. However, the catalyst is NO because it is used up in the first equation and is regenerated in the second equation. So NO isn't used up **overall**.

[Total: 13]

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

Phenol is a weak Brønsted–Lowry acid.

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

(a) **Define the following terms:**

(i) **A *Brønsted–Lowry* acid,**

[1]

Candidate style answer	*Examiner's commentary*
A proton donor	

(ii) **A *weak* acid.**

[1]

Candidate style answer	*Examiner's commentary*
An acid that partially dissociates	

(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 2 base 1 acid 2	

(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.**

$$M_r\ C_6H_5OH = 94$$

$$[C_6H_5OH(aq)] = \frac{4.7}{94} = 0.050\ \text{mol dm}^{-3}$$

$$1.3 \times 10^{-10} \approx \frac{[H^+(aq)]^2}{0.050}\ \text{mol dm}^{-3}$$

$$[H^+] = \sqrt{1.3 \times 10^{-10} \times 0.050} = 2.55 \times 10^{-6}\ \text{mol dm}^{-3}$$

$$pH = -\log[H^+] = -\log 2.55 \times 10^{-6} = 5.59$$

[5]

Candidate style answer	Examiner's commentary

(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.

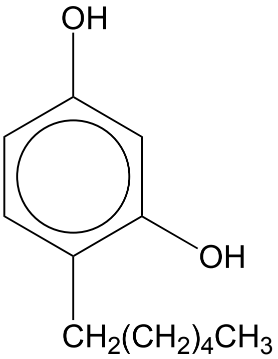
Use your knowledge of buffer solutions to determine the concentration of sodium phenoxide solution that the student would need to mix with the 0.200 mol dm^{-3} phenol solution.

[3]

Candidate style answer	*Examiner's commentary*
$[H^+(aq)] = 10^{-pH} = 10^{-8.71} = 1.99 \times 10^{-9}$ mol dm^{-3} $K_a = \frac{[H^+(aq)]\,[C_6H_5O^-(aq)]}{[C_6H_5OH(aq)]}$ $\therefore [C_6H_5O^-(aq)] = \frac{K_a \times [C_6H_5OH(aq)]}{[H^+(aq)]} =$ $\frac{1.3 \times 10^{-10} \times 0.200}{1.99 \times 10^{-9}}$ $= 0.13$ mol dm^{-3}	The correct answer has been obtained but rather luckily. As two solutions were mixed together, the actual concentrations of each component in the buffer solution would have been less than the original concentrations. But because the volumes mixed were equal, the ratio of the concentrations is the same. Had the volumes been different, this would have introduced an error.

(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 sodium ethanoate because a buffer is a mixture of a weak acid and its salt	Excellent responses overall. In **(e)**, the candidate has misinterpreted the question. What is required is a salt of hexylresorcinol, not just the salt of any weak acid.

[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*
$K_c = \dfrac{[CH_3OH]}{[CO]\,[H_2]^2}$	

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

[4]

Candidate style answer	*Examiner's commentary*
$K_c = \dfrac{5.20 \times 10^{-5}}{6.20 \times 10^{-3} \times (4.80 \times 10^{-2})^2} = 3.64$ units: $\dfrac{mol\ dm^{-3}}{mol\ dm^{-3} \times (mol\ dm^{-3})^2} = dm^6\ mol^{-2}$ $K_c = 3.64$ units: $dm^6\ mol^{-2}$	Unfortunately 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 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 fewer moles of gas 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
None	

(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 because the decreased K_c value means that the products (on the top of the expression) will decrease and the reactants (on the bottom of the expression) will increase.	

(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 because high temperature favours 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*
$CH3OH + 1\frac{1}{2} O2 \longrightarrow CO2 + 2H2O$	

(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 so there is more attraction from the nucleus	

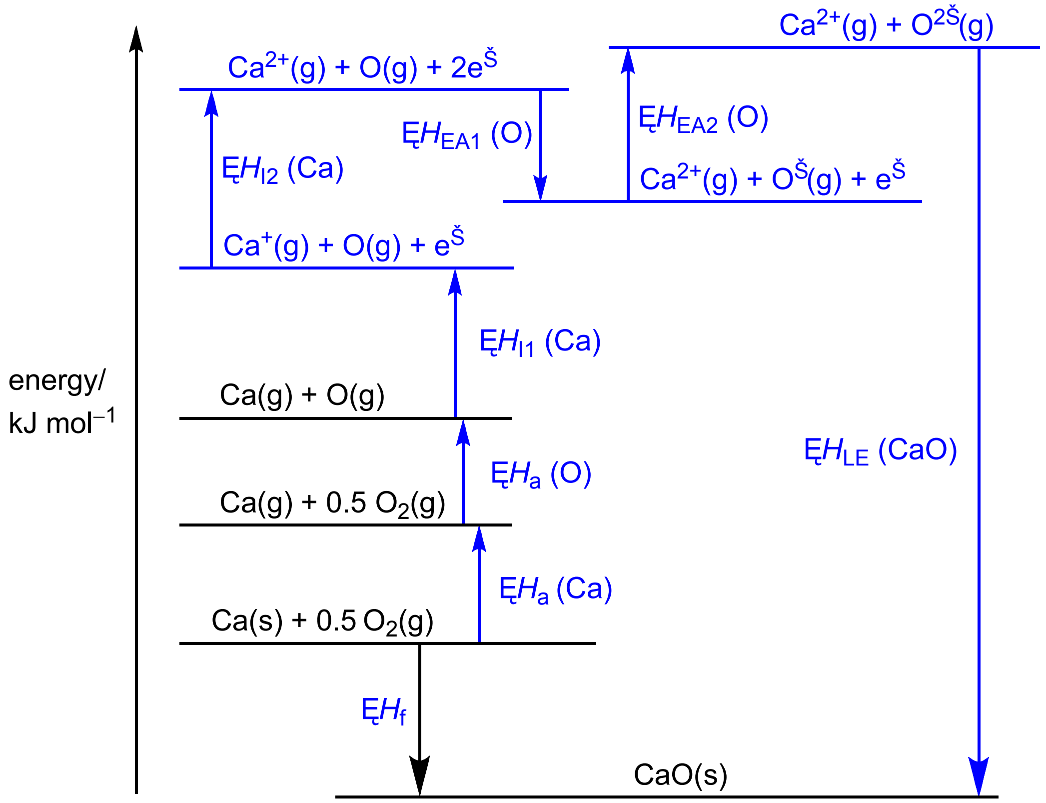
(ii) **Suggest why the second electron affinity of oxygen is positive.**

[2]

Candidate style answer	*Examiner's commentary*
The O^- ion is negative and will repel an electron because they are both negative.	The responses in both part of **(a)** are only partway there. There is no discussion of energy or a response that explains why the second ionisation energy is greater or why the electron affinity is positive. In **(i)**, the consequence of the increased attraction is that more energy is needed to remove an electron. In **(ii)**, the candidate should have stated that 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 = -635 -(178 + 248 + 590 + 1150 + (-141) + 791) = -3451 kJ mol^{-1} lattice enthalpy = -3451 kJ mol^{-1}	

(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 has a weaker attraction for O^{2-}. This means that the lattice enthalpy for MgO will be less than for CaO.	Lattice enthalpies are negative values and use of the words 'more' and 'less' should not be used unless qualified for comparing negative numbers (–2 is actually 'more' than –4!). The candidate should have stated that the lattice enthalpy of MgO is less exothermic or less negative'. By using just 'less', this is a case is which 'less means more'! .

(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} $\Delta H^{\ominus} = 525$ 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} $\Delta S^{\ominus} = 193.6$ 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*
$\Delta G = \Delta H - T\Delta S$ To be feasible, $\Delta G < 0$ The minimum temperature is when $0 = \Delta H - T\Delta S$ $\therefore \Delta S = \frac{193.6}{1000} = 0.1936$ kJ mol^{-1} $\therefore T = \frac{\Delta H}{\Delta S} = \frac{525}{193.6} = 2.71$ K minimum temperature = 2.71 K	Unfortunately, the candidate has not ensured that entropy and enthalpy are in the same units. Entropy values or typically shown in J mol^{-1} and enthalpy values in kJ mol^{-1}. Before the last stage, ΔS should have been divided by 1000 to give a value of 0.1936 kJ mol^{-1} (or ΔH multiplied by 1000 to J mol^{-1}) The correct answer should have been 1000 times larger: 2712 K.

[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*
Ecell is the difference so Ecell $= 0.26 - (-0.44) = 0.18$ V Ecell = 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*
Hydrogen is less positive so this goes left and is reversed. The hydrogen one is doubled to get $4e^-$ $H_2(g) \longrightarrow 4H^+(aq) + 4e^-$ $O_2(g) + 4H^+(aq) + 4e^- \rightleftharpoons 2H_2O(l)$ Add to get overall: $2H_2 + O_2 \rightarrow 2H_2O$	

(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, only water is formed so there are no polluting gases. Fuel cell are more efficient that burning fossil fuels Disadvantages: Hydrogen is an inflammable explosive gas and is difficult to store. It has to be made first and this needs energy.	Excellent understanding.

[Total: 9]

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

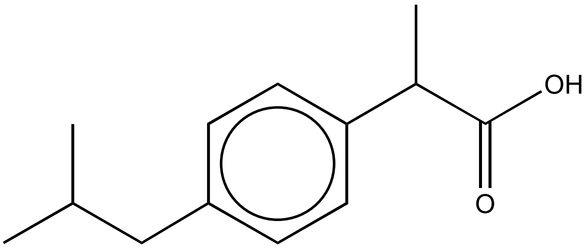
(a) **An oxide of nitrogen is used as a general anaesthetic by dentists.**
This oxide contains 63.64% N by mass, and has a density of 1.833 g dm^{-3} at room temperature and pressure.

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

[3]

Candidate style answer	*Examiner's commentary*
Ratio N : O = $\frac{63.64}{14}$: $\frac{36.36}{16}$ = 4.56 : 2.27 = 2 : 1. So the empirical formula = N_2O 1 dm^3 of the gas has a mass of 1.833 g So 24 dm^3 of the gas has a mass of 1.833 x 24 = 44 N_2O weighs 44 so molecular formula is N_2O	

(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 $C12H17COOH + Mg \longrightarrow C12H17COOMg + \frac{1}{2}H2$	The candidate seems to have forgotten a basic fact: Group 2 elements, such as magnesium, forms ions with a 2+ charge. The correct formula of the salt would be $(C_{12}H_{17}COO)_2Mg$. The correct equation would then be: $2C_{12}H_{17}COOH + Mg \longrightarrow (C_{12}H_{17}COO)_2Mg + H_2$

(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
For lidocaine, M_r = 236 moles lidocaine = $\frac{100 \times 10^{-3}}{236}$ = 4.24 x 10^{-4} 4.24 x 10^{-4} in 5 cm^3 , so 4.24 x 10^{-4} x 200 moles in 1000 cm^3. So concentration of lidocaine = 0.08 mol dm^{-3} ✓ concentration = 0.8 mol dm^{-3}	Another strange lapse for such a strong candidate. The final answer should have been given to 3 significant figures as all values in the question are to this precision. The answer of 0.8 against the actual calculated value of 0.848 introduces a 6% rounding error. This is a basic error and loss of marks such as this could prove costly for a candidate aiming for a high grade.

(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
moles eugenol = $\frac{1.394}{164}$ = 0.0085 moles CO_2 = $\frac{3.74}{44}$ = 0.085 moles C = moles CO_2 = 0.085 mole ratio eugenol : C = 0.0085 : 0.085 = 1 : 10. So there must be 10 C atoms in eugenol moles H_2O = $\frac{0.918}{18}$ = 0.051 moles H = moles H_2O x 2 = 0.102 mole ratio C : H = 0.085 : 0.102 = 1 : 1.2 = 10 : 12. So there must be 12 H atoms in eugenol So in eugenol, $C_{10}H_{12}$ is 132, so O is 164 - 132 = 32. So there must be 2 Os. Molecular formula of eugenol = $C_{10}H_{12}O_2$	

[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.

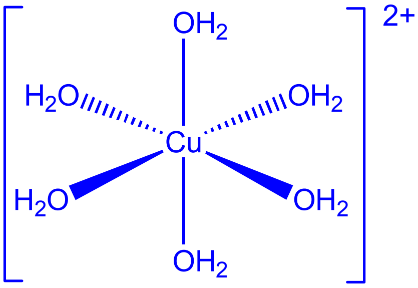
In your answer you should make clear how any observations provide evidence for the type of reaction discussed. [11]

Candidate style answer	*Examiner's commentary*

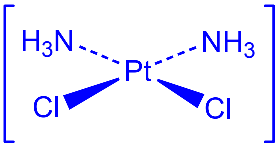
(b) Describe, using suitable examples and diagrams, the different shapes and stereoisomerism shown by complex ions.

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 an ion with a partly filled d-orbital A complex ion is a central metal ion surrounded by ligands A ligand has a lone pair of electrons that can be donated to a metal ion to form a dative covalent bond Transition metal ions take part in precipitation reactions eg $Cu^{2+}(aq) + 2OH^-(aq) \longrightarrow Cu(OH)_2(s)$ $Cu(OH)_2$ is a blue precipitate, showing that a precipitation reaction has taken place Transition metal ions take part in ligand substitution reactions eg $[Cu(H_2O)_6]^{2+}(aq) + 4NH_3(aq) \longrightarrow [Cu(NH_3)_4(H_2O)_2]^{2+}(aq) + 4H_2O\ (l)$ The pale blue solution turns into a deep blue solution. This colour change suggests that a different ligand is now attached to the Cu^{2+} ion. Transition metal ions take part in redox reactions eg $5Fe^{2+} + MnO_4^- + 8H^+ \longrightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$ The deep purple manganate colour is decolourised and this shows that the MnO_4^- ions have reacted. Many transition metal complexes have an octahedral shape, e.g. $[Cu(H_2O_6)]^{2+}$ with bond angles of 90 °.	



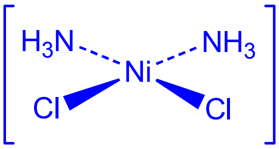
There are also square planar shapes, as in platin, $PtCl_2(NH_3)_2$. The bond angle is also 90 °



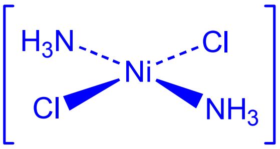
Stereoisomerism is when the atoms are connected together in the same way but are connected differently. There are two types is stereoisomerism in transition metal complexes. cis-trans and optical.

For cis-trans isomerism, you need two different ligands with at least two of each. The cis-isomer has ligands that are the same are next to each other. In the trans isomer, has ligands that are the same are opposite. Both octahedral and square planar complexes can have cis-trans isomers.

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



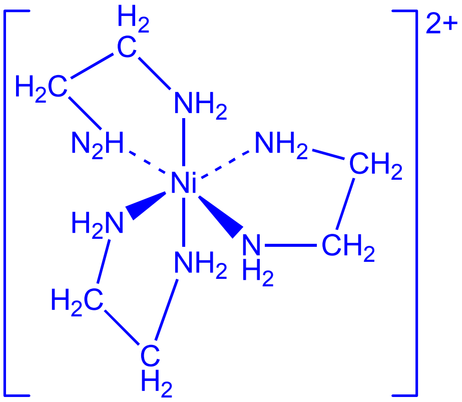
cis

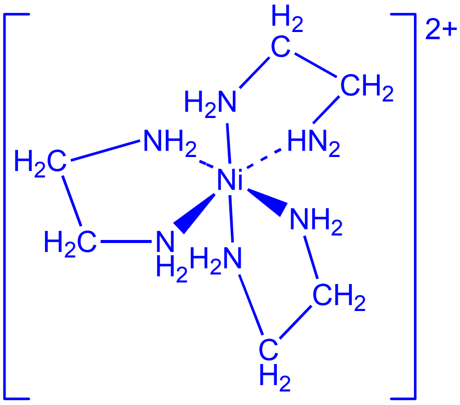


trans

Optical isomerism happens when you have multidentate ligands such as $H_2NCH_2CH_2NH_2$ ('en'). You need an octahedral complex ion and the two isomers are non-superimposable mirror images of one another.

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





[Total: 20]

Overall Banding High

An excellent response throughout. The candidate has clearly learnt this work very thoroughly and has constructed a well-sequenced and extremely clear response. The use of carefully drawn 3D diagrams greatly enhances the candidate’s answer.

Paper Total: [100]