

OCR A-LEVEL CHEMISTRY B (SALTERS) • H433

CHEMISTRY



EXAM QUESTION PACK

ELEMENTS OF LIFE (EL): ENERGY AND MATTER

SCORE

/46

PERCENTAGE

%

STEMUP

These questions belong to OCR, not to us.

The examination questions, mark schemes and examiner comments in this pack were written and published by OCR. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with OCR and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. OCR has not endorsed, approved or been involved in the production of it. OCR and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

OCR publishes its past papers, mark schemes and examiner reports free of charge. Always check the current specification at ocr.org.uk before you revise, because content and wording can change between series.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

1 What has the longest wavelength?

- A Ultraviolet radiation
B Green light
C Red light
D Blue light

Your answer

[1]

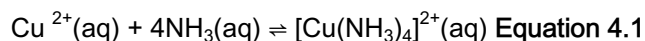
2 In 1869 a green emission line was seen in the Sun during an eclipse. At first this was thought to be caused by a new element. Later it was found to be due to a highly ionised form of iron, Fe^{13+} .

* Describe the appearance and origin of the emission spectrum of the Sun and explain how the lines can be used to identify elements.

[6]

[6]

- 3 A complex ion forms when ammonia solution is added to copper(II) sulfate solution. The equation for the reaction can be represented as below.



- (i) High concentrations of ammonia in horse's urine can be a sign of infection. Adding a fixed amount of copper(II) sulfate solution to a given volume of urine produces the deep blue / purple ion, $[\text{Cu}(\text{NH}_3)_4]^{2+}(\text{aq})$ in equation 4.1.

Suggest how the production of this ion can be used as a measure of the ammonia content in the horse's urine.

----- [2]

- (ii) Write an equation for the equilibrium constant, K_c , of the reaction in equation 4.1.

[1]

- (iii) A solution initially contains 0.10 mol dm^{-3} of $\text{Cu}(\text{II})$ ions and 0.40 mol dm^{-3} of ammonia. At equilibrium, the concentration of $[\text{Cu}(\text{NH}_3)_4]^{2+}$ formed is x .

Write an expression for the equilibrium constant K_c in terms of x .

[2]

- (iv) Two students wanted to measure the concentration of ammonia in the complex solution at equilibrium. One suggested that they titrate samples of the complex solution with standard sulfuric(VI) acid. The other said the results would be inaccurate.

Comment on who is correct and give a reason for your answer.

- 4 Ancient paintings have been discovered in caves. The paintings were made using *ochre*, a natural pigment. Ochre owes its colour to the presence of $\text{FeO}(\text{OH}) \cdot n\text{H}_2\text{O}$.

The presence of iron can be identified from the atomic emission spectrum of ochre.

Describe the appearance of an atomic emission spectrum and explain how iron could be identified.

[4]

5 Strontium has an intense line at wavelength 4.08×10^{-5} cm in its emission spectrum.

(i) Explain how such lines are formed and why they are at specific frequencies.

----- [3]

(ii) Calculate the energy (in kJ mol^{-1}) associated with this line.

energy = _____ kJ mol^{-1} [3]

The element was first thought to be barium, which was known at the time. However, strontium gave a red flame colour when heated and barium's flame is green.

This image shows a blank sheet of white paper with horizontal dashed lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no other markings or text on the page.

- Explain what affects the frequency of radiation absorbed and why the decomposition products look yellow.

This image shows a blank sheet of white paper with horizontal dashed lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no other markings or text on the page.

(ii) Calculate the energy (in kJ mol^{-1}) that corresponds to a wavelength of 350 nm absorbed by lignin.

(1 nm = 10^{-9} m)

energy = ... kJ mol^{-1} [3]

8 Which statement about an atomic emission spectrum is correct?

- A It occurs when electrons absorb energy.
- B The wavelength of a line is proportional to the energy lost by electrons.
- C The wavelengths of the lines are the same as in an absorption spectrum of the same element.
- D The lines in the emission spectrum of lithium give a yellow colour to a lithium flame.

Your answer

[1]

- 9 Some students are given a mixture of magnesium carbonate with another Group 2 carbonate. They dissolve the mixture in an acid. They test the solution of salts formed as shown in the table below.

Test	Result
Flame test	Green flame
Add dilute nitric acid followed by silver nitrate solution	White precipitate

- (i) Name the acid that the students used to dissolve the mixture of carbonates.

-----[1]

- (ii) Name the other Group 2 carbonate that was mixed with the magnesium carbonate.

-----[1]

10 Strontium carbonate is used in fireworks to colour the flames red.

The red colour comes from lines of specific frequency in the atomic emission spectrum of strontium.

Explain how these lines are formed.

[3]

11 Which statement about electromagnetic radiation is correct?

- A Infrared radiation has a shorter wavelength than visible light.
- B The frequency of infrared radiation is higher than visible light.
- C Infrared and ultraviolet radiation travel at the same speed.
- D Visible light has a higher frequency than ultraviolet radiation.

Your answer

☐

[1]

END OF QUESTION PAPER

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
1			C	1	
			Total	1	
2			<i>Please refer to point 10 of the marking instructions of this mark scheme for guidance on how to mark this question.</i> Level 3 (5–6 marks) Learners demonstrate knowledge and understanding of the appearance and origin of atomic emission spectra and can apply this knowledge of scientific ideas in explaining how the lines can be used to identify elements. <i>The answer is logical and well structured</i> Level 2 (3–4 marks) Learners demonstrate reasonable knowledge and understanding of the appearance and origin of atomic emission spectra. They can partially apply this to explaining how the lines can be used to identify elements. <i>The points made are logical and well structured</i> Level 1 (1–2 marks) Learners either demonstrate some knowledge and understanding of the appearance and origin of atomic emission spectra and can begin to apply this to explaining how the lines can be used to identify elements or they show reasonable understanding in either area. <i>Such points as are made are in a logical sequence</i> 0 marks No response or no response worthy of credit.	6	Indicative scientific points may include: Appearance and origin - atoms absorb energy - electrons move up energy levels - energy levels quantised (electrons) drop back down - emit light $\Delta E = h\nu$ - give coloured lines How lines can be used - atoms of each element have their own specific energy levels - thus different gaps - thus different frequency lines - frequencies of lines can be checked against a database ALLOW points made on a labelled diagram
			Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
3		i	intensity of colour OR absorbance of (suitable wavelength) light ✓ gives a measure of concentration (of complex / ammonia) OR (directly) proportional to concentration (of complex / ammonia) ✓	2	
		ii	$= \frac{[\text{Cu}(\text{NH}_3)_4]^{2+}}{[\text{Cu}^{2+}][\text{NH}_3]^4}$ ✓	1	
		iii	$\frac{x}{(0.1 - x)(0.4 - 4x)^4}$ correct apart from a wrong value for $[\text{NH}_3]$ ✓ (0.4 - 4x) for $[\text{NH}_3]$ ✓	2	ALLOW ECF from (ii)
		iv	Inaccurate / second student correct because Reaction of (OH ⁻ in) ammonia solution with H ₂ SO ₄ causes equilibrium to move so all the ammonia is neutralised (AW) OR equilibrium 4.1 shifts to the left as the acid reacts with the ammonia ✓ so titre / measured concentration will be too large ✓	2	
			Total	7	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
4			Spectrum is coloured lines → on dark/black (background) ✓ lines/spectrum/frequencies are unique/characteristic/specific to an element/Fe ✓ because energy gaps are unique OR compare with known data AW ✓	4	IGNORE atom, compound and molecule must imply 'gaps between levels' not just 'levels' to score Examiner's Comments Some candidates said that a line spectrum was coloured lines on a black background and that each element had a unique spectrum. Iron could be identified in ochre by comparison with a known iron spectrum. Many went into detail about how the spectrum was formed, which was not required by the question. Some omitted a description of the spectrum while others were not clear that the spectra were unique to <i>elements</i>, not atoms or compounds.
			Total	4	
5		i	<u>electrons</u> are promoted(AW) to higher <u>energy levels</u> by heat/energy ✓ drop down (energy levels) emitting light/radiation/photon ✓ energy dropped proportional to frequency/ $\Delta E = h\nu$ ✓	3	NOT promoted by light/radiation
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 293 (kJ mol⁻¹) award 3 marks Use of $\Delta E = hc/\lambda$ ✓ $\Delta E = 6.63 \times 10^{-34} \times 6.02 \times 10^{23} \times 3 \times 10^8 / 4.08 \times 10^{-7} \times 1000$ ✓ = 293 kJ mol⁻¹ ✓	3	ALLOW two or more sf ALLOW from a substituted expression ALLOW ecf for calculation of expression omitting or misplacing one of the terms
			Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
6			<i>Please refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question.</i> Level 3 (5–6 marks) Learners are able to explain the origin of colour, electron transitions that cause the lines and the application of the lines to identification of elements. They give most of the points in all 3 sections <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Learners clearly describe points from at least two of the sections or some coverage of all. <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Learners describe points from at least one of the sections or two points in total. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks No response or no response worthy of credit.	6	Indicative scientific points may include: AO1.1 Origin of colour: • Colour is related to certain visible frequencies / wavelengths of light. • $(\Delta)E = h\nu$ AO1.1 Electron transitions: • Excitation of electrons by absorbing energy (NOT em radiation) • Release of em radiation as electron drops down energy levels. • energy levels are quantised / discrete AO2.1 Use in identification: • Energy levels and hence gaps are unique to the element. • Comparison of spectrum showed it did not match any elements known at the time. (Comparison with barium alone only partially matches this criterion). ALLOW points made on a labelled diagram. Examiner Comments Most candidates made a reasonable attempt at this question and some answers were excellent. The most common mistakes made highlighted confusion with absorption and emission and absorbing light and transmitting the complementary colours. The analysis of the light providing proof that strontium was a new element proved more difficult to explain, some explanations confined themselves just to flame colour or a comparison with barium only.
			Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
7		i	<i>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.</i> Level 3 (5–6 marks) Shows a good understanding of all three areas <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Shows a sound understanding of at least two areas. OR Discusses all three areas, demonstrating a sound understanding of one area <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 Marks) Shows some understanding of one area. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> Level 0 (0 marks) <i>No response or response has no merit.</i>	6	Indicative scientific points include Why radiation absorbed • electrons move to higher energy levels / shells • absorbing light / radiation • frequency absorbed $\Delta E = h\nu$ (allow $E = h\nu$ if clear reference to energy gap) Affect of structure on frequency of radiation • amount of delocalisation affects ΔE / frequency • smaller delocalisation, larger ΔE / frequency • lignin has smaller chromophore / less delocalisation than decomposition prods Source of yellow colour • uv higher frequency / larger ΔE than visible • look yellow because they absorb the complementary colour / blue / violet For answers that talk about electrons falling and releasing radiation / light / colour impedes the line of reasoning and should result in the lower mark within a level being awarded. Examiner's Comment: This question produced a full range of marks and allowed the more able candidates to demonstrate their understanding of this topic. Most candidates were able to explain what happens to electrons when they absorb radiation and linked this to the idea of quantisation of energy. They also linked the amount of energy to the appropriate frequency absorbed and that this could be used to identify the colour of the decomposition products as being complimentary to the frequency / colour

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					absorbed. More able candidates also discussed the nature of the chromophores in lignin and in its decomposition products and correctly stated that when the degree of delocalisation in the chromophore increased, this reduced the size of the energy gap between the ground state and the excited state and that this resulted in the decomposition products absorbing light in the blue(or violet) part of the visible spectrum and so the complimentary colour was reflected. Some candidates did lose marks for stating that the colour produced was a result of electrons being promoted to a higher energy level and then dropping back to their ground state with the release of energy in the visible spectrum that resulted in the paper appearing yellow. This question gave very clear differentiation between the candidates, strong candidates produced a very clear and well organised response that addressed all three areas in depth. Whereas, weaker candidate responses were characterised by a lack of organisation, or in producing a response that either only addressed one area, or gave a brief account of what happens when radiation is absorbed by molecules and how this produced a yellow colour.
		ii	FIRST CHECK ANSWER LINE <i>If answer = 342 (kJ mol⁻¹) award 3 marks</i> Rearrangement of $E = hv$ and $c = v\lambda$ to $E = hc/\lambda$ ✓ $E = 6.63 \times 10^{-34} \times 3 \times 10^8 / 3.5 \times 10^{-7}$ (J per atom) OR $E = 6.63 \times 10^{-34} \times 8.57 \times 10^{14}$ ✓ multiply by N_A and divide by 1000 and evaluate $(6.63 \times 10^{-34} \times 3 \times 10^8 \times 6.02 \times 10^{23} / 3.5 \times 10^{-7} \times 1000) = 342 \text{ kJ mol}^{-1}$ ✓	3	ALLOW ecf MP2 subsumes MP1 and scores 2 marks Examiner's Comment: This question was generally well answered with many candidates scoring at least 2 marks for the correct rearrangement of $E = hv$ and $c = v\lambda$, and then the correct calculation of the energy of the photon absorbed. More able candidates subsequently calculated the energy per mole correctly as 342kJ mol⁻¹.
			Total	9	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
8			C	1	
			Total	1	
9		i	hydrochloric (acid) / HCl ✓	1	IGNORE 'dil' / 'conc'
		ii	barium (carbonate) ✓	1	ALLOW BaCO₃ but NOT Ba on its own <u>Examiner's Comments</u> In general, these final two elements of question 1 were well answered by most candidates. The only common errors were the use of sulfuric acid in e(i), or the presence of calcium (carbonate) in e(ii). Both of these potentially came as a result of misinterpreting the cause of the white precipitate stated in the results table.
			Total	2	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
10			electrons raised/excited to higher energy levels (by heat) ✓ fall and release energy/visible light/photon ✓ frequency of energy/light/photon proportional to gap between energy levels / $(\Delta)E = h\nu$ ✓	3(AO1.2 x 3)	DO NOT ALLOW answers where energy source is e/m radiation <u>Examiner's Comments</u> Many candidates scored at least 2 marks here, with higher ability candidates scoring all 3 marks. Candidates were able to outline the three components, i.e. excitation of ground state electrons, returning to ground state from the excited state releasing energy/light of a particular frequency, and either quoting $E = h\nu$ linked to the frequency emitted, or identified that the frequency was proportional to the energy gap between the quantised energy levels within the strontium atom. Marks were often lost for stating that the atoms absorbed electromagnetic radiation (e.g. light) in order to excite and promote the electron. This was not allowed as we were looking at the use of strontium in fireworks where the energy source would be heat (thermal), although the term energy used on its own was allowed. Marking point two was usually scored; the majority of candidates knew that the coloured line(s) (on a black background) were produced as a result of the electron being in an unstable state and returning to its ground state energy level, emitting a light / a photon of a frequency associated with the red colour observed. Many candidates also identified that the frequency of light emitted was proportional to the gap between energy levels OR made correct use of $E=h\nu$. However, lower ability candidates often did not score this mark as they struggled to link these ideas correctly.
			Total	3	
11			C	1 (AO1.1)	
			Total	1	