End of topic questions

Topic review

1. Using your knowledge from the *Structure 3.1* topic, answer the guiding question as fully as possible:

   How does the periodic table help us to predict patterns and trends in the properties of elements?

Exam-style questions

Multiple-choice questions

2. Which of the following does **not** apply to zinc?

   A. metal
   B. d-block element
   C. transition element
   D. element

3. Which of the following oxides forms an acidic solution when added to water?

   I. SiO_2
   II. SO_2
   III. SrO

   A. II only
   B. III only
   C. I and II only
   D. II and III only

4. Which of the following trends does **not** explain why electronegativity increases across periods?

   A. increasing number of valence electrons
   B. atomic radius decreases
   C. nuclear charge increases
   D. constant shielding

5. Which of the following shows a second ionization energy?

   A. $X(g) \rightarrow X^{2+}(g) + 2e^-$
   B. $X^-(g) + e^- \rightarrow X^{2-}(g)$
   C. $X^{2+}(g) \rightarrow X^{3+}(g) + e^-$
   D. $X^+(g) \rightarrow X^{2+}(g) + e^-$

6. Which of the following represents the total amount of energy, in kJ, required to form one mole of oxide ions from one mole of oxygen atoms?

   (1st EA of oxygen = –141 kJ mol^{-1}; 2nd EA of oxygen = 753 kJ mol^{-1}; $N_A = 6.02 \times 10^{23}$ mol^{-1})

   A. –141
   B. $-141 \times 2 \times 6.02 \times 10^{23}$
   C. $(-141 + 753) \times 6.02 \times 10^{23}$
   D. –141 + 753

7. Which pair of elements would react most vigorously?

   A. Cs and F_2
   B. Li and I_2
   C. Cs and I_2
   D. Li and F_2

8. Which statement about the halogens is correct?

   A. Cl_2 is a weaker reducing agent than F_2
   B. I_2 will oxidize Br^-
   C. I_2 has a lower tendency to be reduced than Br_2
   D. Cl_2 will reduce I^-

9. Deduce the oxidation state of nitrogen in sodium nitrate.

   A. +1 B. +2 C. +5 D. +6

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10. Which of the following is **not** a typical property of transition elements?

    A. catalytic properties
    B. variable oxidation states
    C. low electrical conductivity
    D. complex ion formation

11. Which of the following statements explains why transition metal compounds are coloured?

    A. Electrons absorb energy when they move to a higher-energy d-orbital
    B. Electrons release energy when they drop down to a lower-energy level
    C. Transition elements have variable oxidation states
    D. Electrons are delocalized in transition elements

12. What is the oxidation state of cobalt in the complex ion $[CoCl_4]^{2-}$?

    A. –2 B. 0 C. +2 D. +4

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13. What is the ligand in the complex $[NH_4]_2[Fe(H_2O)_6][SO_4]_2$?
    A. Fe^{2+}
    B. $[SO_4]^{2-}$
    C. H_2O
    D. $[NH_4]^+$
14. $[Ni(NH_3)_6]^x$ is a complex ion with nickel in the +2 oxidation state. What is the overall charge, *x*, of the complex?
    A. 0
    B. 1+
    C. 2+
    D. 3+

Extended-response questions

15. This question is about the halogens. The halogens are in group 17 of the periodic table.
    a. Explain why the atomic radius of the halogens increases down the group. [2]
    b. Explain why fluorine has a greater electronegativity than oxygen. [2]
    c. Explain why the chloride ion has a greater radius than the chlorine atom. [2]
    d. When chlorine gas is bubbled through aqueous potassium bromide, an orange-brown liquid is produced.
        i. Write a balanced equation, including state symbols, for the reaction described above. [2]
        ii. Explain why this reaction occurs. [2]
16. The alkali metals react vigorously with water.
    a. State the group number of the alkali metals. [1]
    b. Explain why the ionization energy of the alkali metals decreases down the group. [2]
    c. Phenolphthalein indicator is added to a large container full of water. Then, a small piece of sodium is added to the water.
        i. Describe and explain the change in the colour of the indicator. [1]
        ii. Suggest a value for the pH of the solution in the container once the reaction has ended. [1]
    d. Write a balanced equation, including state symbols, for the reaction of rubidium with water. [2]
17. This question is about acid deposition.
    a. Explain, using relevant chemical equation(s), why rain is naturally acidic. [2]
    b. Explain why burning coal leads to the production of acid rain. [2]
    c. Figure 12 on page 243 shows some of the consequences of acid deposition.
        i. List the five consequences of acid deposition shown in figure 12. [1]
        ii. Choose **one** of the consequences of acid rain. Suggest how it can be offset. [2]
18. a. Sketch a graph showing the first 10 ionization energies of copper. [2]
    b. State the abbreviated electron configuration of copper. [1]
    c. State the full electron configuration of a copper(II) ion. [1]
19. Explain why aqueous copper(II) nitrate forms a coloured solution, whereas aqueous zinc nitrate is colourless. [2]

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20. When excess hydrochloric acid is added to aqueous cobalt(II) ions, a ligand exchange reaction takes place, causing the colour of the solution to change from pink to blue:

$$[Co(H_2O)_6]^{2+} + 4Cl^- \rightleftharpoons [CoCl_4]^{2-} + 6H_2O$$

pink blue

    a. The pink $[Co(H_2O)_6]^{2+}$ complex ion absorbs light with a wavelength of approximately 540 nm. Calculate the energy difference between the split d orbitals of cobalt in this complex ion. [2]
    b. Explain how the colour change in this reaction shows that chloride ions are weaker ligands than water molecules. [2]
21. Explain, by referring to successive ionization energies, why titanium can exist in variable oxidation states, but calcium only occurs in the +2 oxidation state. [2]

End of topic questions

Topic review

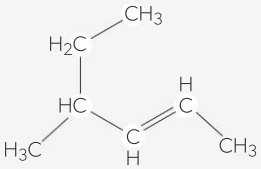
1. Using your knowledge from the *Structure 3.2* topic, answer the guiding question as fully as possible:

   How does the classification of organic molecules help us to predict their properties?

Exam-style questions

Multiple-choice questions

2. What is the name of the following compound, applying IUPAC rules?



   A. 4-methylhex-2-ene

   B. 4-ethylpent-2-ene

   C. 2-ethylpent-3-ene

   D. 3-methylhex-4-ene

3. Which of the following is in the same homologous series as CH_3OCH_3?

   A. CH_3COCH_3

   B. CH_3COOCH_3

   C. $CH_3CH_2CH_2OH$

   D. $CH_3CH_2CH_2OCH_3$

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4. Which of the following analytical techniques would show the difference between propan-2-ol, $CH_3CH(OH)CH_3$, and propanal, CH_3CH_2CHO?

   I. mass

   II. infrared

   III. ^{1}H NMR

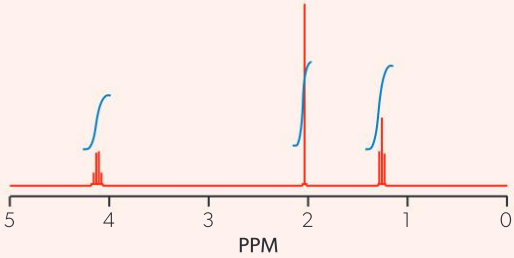
   A. I and II only

   B. I and III only

   C. II and III only

   D. I, II and III

5. Which substance has the following ^{1}H NMR spectrum?



   A. propane

   B. propanal

   C. ethyl ethanoate

   D. butanoic acid

Extended-response questions

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6. a. State, giving a reason, if but-1-ene exhibits *cis–trans* isomerism. [1]

   b. The reaction which occurs between but-1-ene and hydrogen iodide at room temperature produces the halogenoalkane, 2-iodobutane. State, giving a reason, if the product of this reaction exhibits stereoisomerism. [1]

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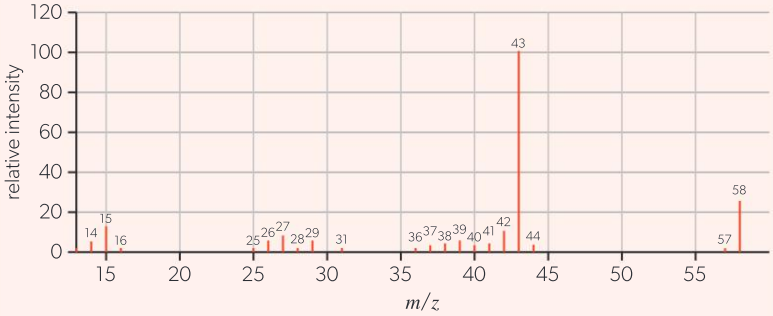
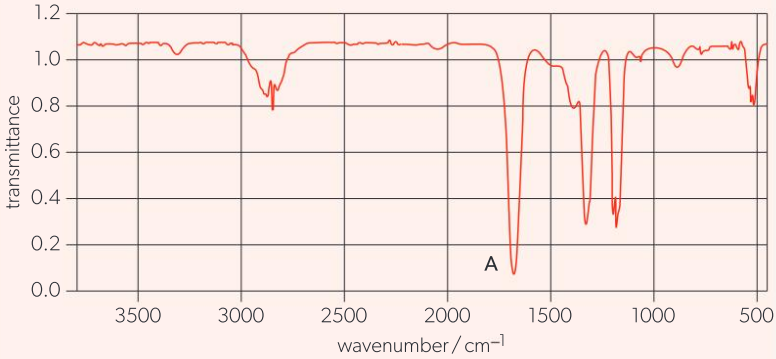
7. Organic chemistry can be used to synthesize a variety of products. Combustion analysis of an unknown organic compound indicated that it contained only carbon, hydrogen and oxygen.

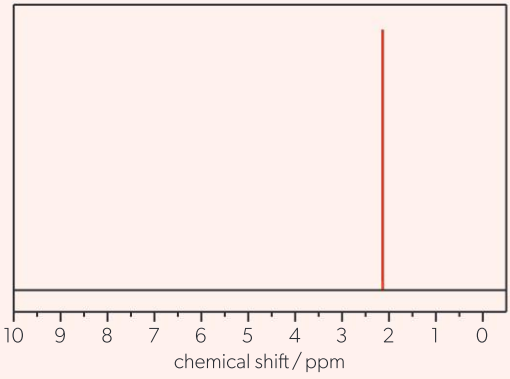
a. Deduce two features of this molecule that can be obtained from the mass spectrum, namely m/z 58 and m/z 43. Use section 22 of the data booklet. [2]



b. Identify the bond responsible for the absorption at **A** in the infrared spectrum. Use section 20 of the data booklet. [1]



c. Deduce information from the ^{1}H NMR and then identify the unknown compound using the previous information, the ^{1}H NMR spectrum and section 21 of the data booklet. [3]



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8. a. Draw the stereoisomers of butan-2-ol using wedge-dash type representations. [1]

   b. Outline how two enantiomers can be distinguished using a polarimeter. [2]

9. Compound **A** is in equilibrium with compound **B**.

   a. Identify the functional groups present in each molecule. [2]

   b. Compound **A** and **B** are isomers. Draw two other structural isomers with the same formula. [2]

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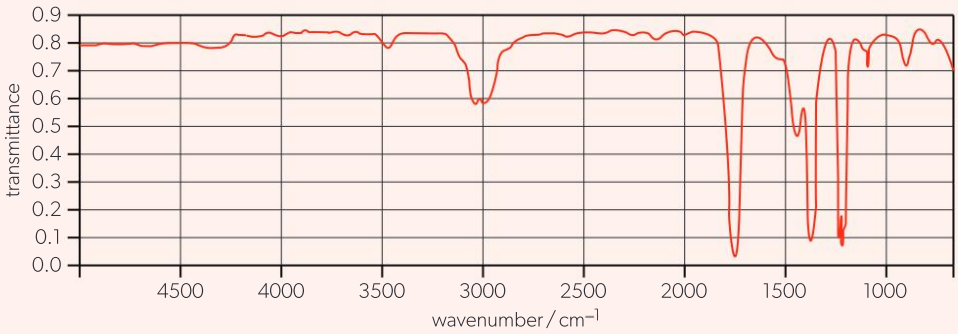
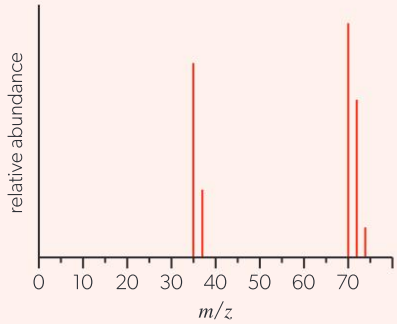
   c. The IR spectrum of one of the compounds is shown:



   Deduce, giving a reason, the compound producing this spectrum. [1]

10. The mass spectrum of chlorine is shown.



   a. Outline the reason for the two peaks at m/z = 35 and 37. [1]

   b. Explain the presence and relative abundance of the peak at m/z = 74. [2]

11. a. Draw the structural formula of ethoxyethane. [1]

   b. Deduce the number of signals and chemical shifts with splitting patterns in the ^{1}H NMR spectrum of ethoxyethane. Use section 21 of the data booklet. [3]

End of topic questions (pages 254–255)

1. Answers will depend on the student, but a possible answer might be: The elements in a particular period have outer electrons in the same energy level while the elements in a particular group have a common number of valence electrons. The chemical properties of the elements depend on their electron configuration, so they change gradually in both periods and groups. Across a period, metallic character of the elements decreases while non-metallic character increases. As a result, the chemical properties of oxides change from basic (for most active metals) through amphoteric (for less active metals and metalloids) to acidic (for non-metals). Down a group, metallic character of the elements increases while non-metallic character decreases. Transition elements with incomplete d-sublevels have variable oxidation states that also demonstrate clear periodic trends.

2. C

3. A

4. A

5. D

6. D

7. A

8. C

9. C

10. C

11. A

12. C

13. C

14. C

15. a. Descending the group, atoms have a greater number of shells/energy levels;

For example, lithium has 2, sodium has 3 and potassium has 4.

b. Fluorine has greater effective nuclear charge / more protons than oxygen

OR

Fluorine has 9 protons and oxygen has 8; Fluorine has a smaller radius than oxygen

OR

Fluorine and oxygen have the same number of shells/energy levels;

c. Cl has 17 electrons AND Cl^- has 18

OR

Cl^- has one more electron than Cl

OR

Cl: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^5$ AND Cl^-: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6$; Cl^- has more electron-electron repulsion hence larger radius;

d. i. $Cl_2(g) + 2KBr(aq) \rightarrow 2KCl(aq) + Br_2(l)$

M1: correct reactants, products and balancing; M2: correct state symbols

Accept $Br_2(aq)$ instead of $Br_2(l)$

ii. Chlorine is more reactive than bromine;

So chlorine displaces bromine from its compound

OR

Chlorine is a stronger oxidizing agent than bromine; So it is reduced, and bromine, oxidised;

Accept converse explanations for bromine being less reactive/weaker oxidising agent.