Write your name here

| Surname | Other names |
|---|---|
| | |

**Pearson Edexcel**
**International**
**Advanced Level**

Centre Number | | | | | |

Candidate Number | | | | |

# Chemistry

## Advanced Subsidiary
## Unit 2: Application of Core Principles of Chemistry

Tuesday 3 June 2014 – Afternoon
**Time: 1 hour 30 minutes**

Paper Reference
**WCH02/01**

**Candidates may use a calculator.**

Total Marks

### Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

### Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

### Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

*Turn over* ▶

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6/6/6/6/3/

P 4 2 9 7 7 A 0 1 2 4

PEARSON

## SECTION A

**Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.**

**1** Hydrogen and iodine gases were mixed at 300 °C and allowed to reach equilibrium.

$$\underset{\text{Colourless}}{H_2(g)} + \underset{\text{Purple}}{I_2(g)} \rightleftharpoons \underset{\text{Colourless}}{2HI(g)} \quad \Delta H = -10 \text{ kJ mol}^{-1}$$

(a) What would you see if the equilibrium mixture was cooled to 250 °C and equilibrium allowed to re-establish?

**(1)**

☒ **A** The mixture goes a darker purple.

☒ **B** The colour gets lighter.

☒ **C** The mixture goes colourless.

☒ **D** No visible change.

(b) The equilibrium mixture at 300 °C was compressed in a gas syringe to occupy a smaller volume. What would be seen immediately after this compression?

**(1)**

☒ **A** The mixture goes a darker purple.

☒ **B** The colour gets lighter.

☒ **C** The mixture goes colourless.

☒ **D** No visible change.

**(Total for Question 1 = 2 marks)**

**2** A concentrated solution of 'bromine water' is an orange colour. The following equilibrium exists in this solution.

$$\underset{\text{Orange}}{Br_2(aq)} + H_2O(l) \rightleftharpoons \underbrace{BrO^-(aq) + Br^-(aq) + 2H^+(aq)}_{\text{Colourless}}$$

What would be the effect, if any, on the colour of the solution, if five drops of dilute sodium hydroxide solution were added to 5 $cm^3$ of the bromine water?

☒ **A** The solution becomes a deeper orange.

☒ **B** The colour of the solution becomes lighter.

☒ **C** The solution goes colourless.

☒ **D** No visible change.

**(Total for Question 2 = 1 mark)**

**3** What is the colour of iodine in the non-polar solvent, cyclohexane?

☒ **A** Black

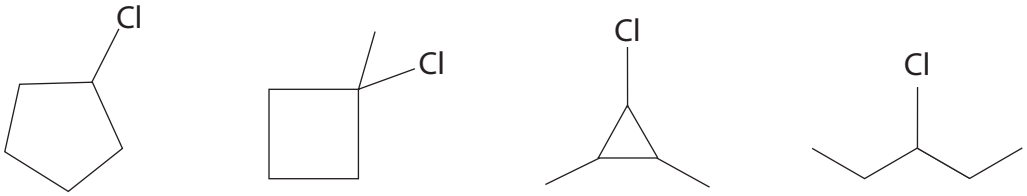
☒ **B** Brown

☒ **C** Purple

☒ **D** Yellow

**(Total for Question 3 = 1 mark)**

**4** The skeletal formulae of some five-carbon halogenoalkanes are shown below.




**A** **B** **C** **D**

(a) Which of the above halogenoalkanes is **not** a structural isomer of the others?

**(1)**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which of the above is **not** a secondary halogenoalkane?

**(1)**

☒ **A**

☒ **B**

☒ **C**

☒ **D**

**(Total for Question 4 = 2 marks)**

**5** The reaction for the preparation of propene from 1-bromopropane is shown below.

$$C_3H_7Br + NaOH \rightarrow C_3H_6 + H_2O + NaBr$$

This reaction is classified as

☒ **A** elimination.

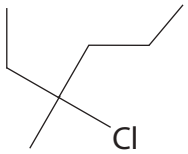
☒ **B** oxidation.

☒ **C** reduction.

☒ **D** substitution.

**(Total for Question 5 = 1 mark)**

**6** The molecule shown below is 3-chloro-3-methylhexane.




It reacts with hot, alcoholic potassium hydroxide to produce a number of different alkenes. Which of the following could be produced from 3-chloro-3-methylhexane?

☒ **A** hex-2-ene

☒ **B** 3-methylhex-1-ene

☒ **C** 3-methylhex-2-ene

☒ **D** 3-methylhex-4-ene

**(Total for Question 6 = 1 mark)**

**7** Which of the following has **not** been a use of chlorofluorocarbons (CFCs)?

☒ **A** Fuels

☒ **B** Dry-cleaning solvents

☒ **C** Fire-retardants

☒ **D** Refrigerants

**(Total for Question 7 = 1 mark)**

**8** Butane is an aerosol propellant now used as an alternative to CFCs. Although it is less destructive to the ozone layer, it has the disadvantage of being

☒ **A** very corrosive.

☒ **B** highly flammable.

☒ **C** hard to evaporate.

☒ **D** highly toxic.

**(Total for Question 8 = 1 mark)**

**9** Which is the **best** explanation of why carbon dioxide, $CO_2$, is a greenhouse gas?

- ☒ **A** It is in high concentration and has a long residence time in the upper atmosphere so it absorbs infrared radiation significantly.
- ☒ **B** It is a polar molecule and so absorbs infrared radiation.
- ☒ **C** It absorbs ultra-violet radiation and re-emits infrared radiation.
- ☒ **D** It has polar bonds that absorb and re-emit infrared radiation.

**(Total for Question 9 = 1 mark)**

**10** The term 'carbon footprint' is concerned with the amount of carbon dioxide produced in generating a certain amount of energy.

The table below gives some data about several fuels.

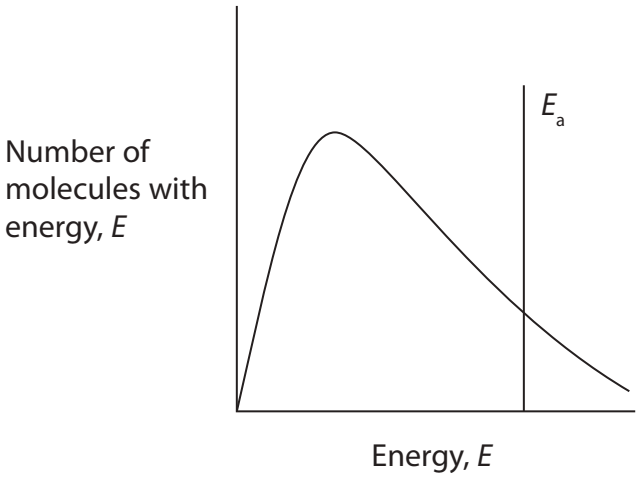
| Fuel | Energy density / MJ $l^{-1}$ | $CO_2$ produced on combustion / g $l^{-1}$ |
|---|---|---|
| Petrol | 32 | 2328 |
| Diesel | 36 | 2614 |
| LPG | 24 | 1533 |
| Bioethanol | 21 | 1503 |

By calculating the mass of $CO_2$ produced per MJ of energy for each fuel, identify which fuel would give the **smallest** carbon footprint.

- ☒ **A** Petrol
- ☒ **B** Diesel
- ☒ **C** LPG
- ☒ **D** Bioethanol

**(Total for Question 10 = 1 mark)**

**11** The diagram below is a Maxwell-Boltzmann distribution of molecular energies.




(a) If the temperature was raised, what would be the effect on the shape of the curve?

**(1)**

☒ **A** The peak would shift to the left and be higher.

☒ **B** The peak would shift to the left and be lower.

☒ **C** The peak would shift to the right and be higher.

☒ **D** The peak would shift to the right and be lower.

(b) Which of the following would shift the activation energy line to the left?

**(1)**

☒ **A** An increase in reactant concentration.

☒ **B** The removal of the product.

☒ **C** The addition of a catalyst.

☒ **D** An increase in temperature.

**(Total for Question 11 = 2 marks)**

**12** The table below gives the boiling temperatures of some alcohols.

| Alcohol | Boiling temperature / °C |
|---|---|
| Ethanol | 78 |
| Propan-1-ol | 97 |
| Butan-1-ol | 117 |

From the data in the table, the boiling temperature of hexan-1-ol is most likely to be

☒ **A** 138°C

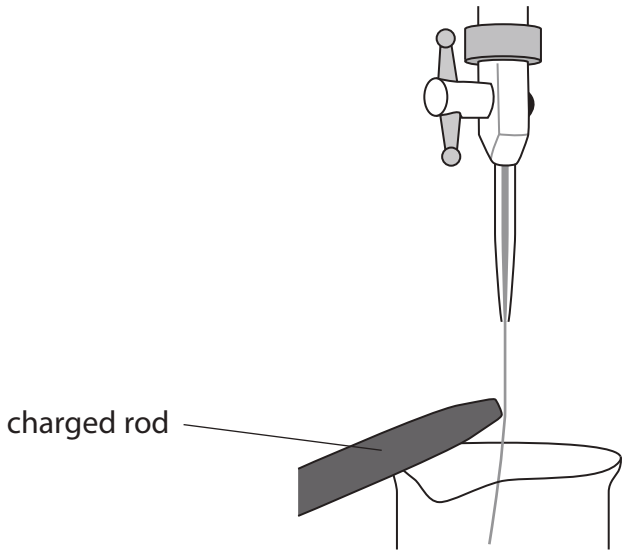
☒ **B** 148°C

☒ **C** 158°C

☒ **D** 168°C

**(Total for Question 12 = 1 mark)**

**13** An experiment to determine the effect of an electrostatic force on a jet of liquid is carried out using the apparatus as shown.




Which of the following liquids would **not** be significantly deflected by the electrostatic force applied?

☒ **A** $CH_3OH$

☒ **B** $CCl_4$

☒ **C** $CHCl_3$

☒ **D** $H_2O$

**(Total for Question 13 = 1 mark)**

**14** Although they have similar relative molecular masses, the boiling temperatures of pentane (36 °C) and butan-1-ol (117 °C) are significantly different. The reason for this is that, in comparison with pentane,

☒ **A** the intermolecular forces between the alcohol molecules are much stronger.

☒ **B** the covalent bonds in the alcohol are stronger.

☒ **C** there are more covalent bonds in the alcohol and so it requires more energy to break all of them.

☒ **D** the molecular shape of the alcohol allows it to form stronger interactions between molecules.

**(Total for Question 14 = 1 mark)**

**15** Compounds such as sodium chloride dissolve in water because the ions interact with the water molecules. The interactions are

☒ **A** dipole-dipole.

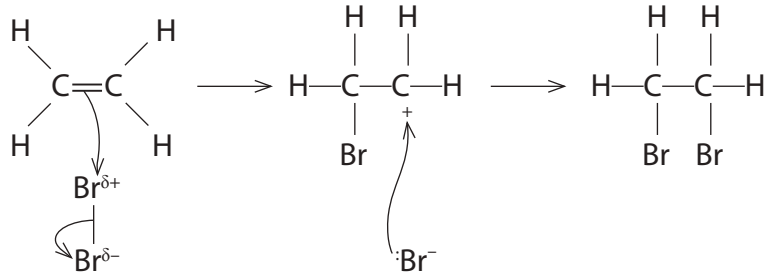
☒ **B** ion-dipole.

☒ **C** hydrogen bonds.

☒ **D** London forces.

**(Total for Question 15 = 1 mark)**

**16** Consider the reaction mechanism shown below.




The bromide ion acts as

☒ **A** an electrophile.

☒ **B** a catalyst.

☒ **C** a free radical.

☒ **D** a nucleophile.

**(Total for Question 16 = 1 mark)**

**17** Nitrogen oxide, NO, can act as a catalyst in the depletion of the ozone layer. Which of the following reactions is most likely to be a step in the process?

☒ **A** $2NO + 2O_3 \rightarrow N_2O_4 + 4O$

☒ **B** $2NO + 2O_3 \rightarrow N_2 + 4O_2$

☒ **C** $2NO + 2O_3 \rightarrow 2NO_2 + 2O_2$

☒ **D** $2NO + 2O_3 \rightarrow N_2O + 3½O_2$

**(Total for Question 17 = 1 mark)**

**TOTAL FOR SECTION A = 20 MARKS**

## SECTION B

**Answer ALL the questions. Write your answers in the spaces provided.**

**18** When concentrated sulfuric acid is added to solid sodium chloride, the gas hydrogen chloride is produced.

(a) Write an equation for this reaction. State symbols are not required.

**(1)**

(b) Fumes of hydrogen chloride gas can be identified by bringing the fumes into contact with another gas, **X**. Identify gas **X** and state the observation you would make.

**(2)**

Gas **X** .....

Observation .....

(c) Chloride ions in solution can be distinguished from other halide ions by the addition of silver nitrate solution followed by dilute, aqueous ammonia.

State what you would see when silver nitrate solution is added to chloride ions, followed by dilute aqueous ammonia.

Suggest why concentrated ammonia should not be used to confirm that silver chloride has been formed.

**(3)**

Observation on addition of $AgNO_3$ .....

Observation on addition of dilute $NH_3$ .....

Reason why concentrated $NH_3$ should **not** be used .....

.....

.....

**(Total for Question 18 = 6 marks)**

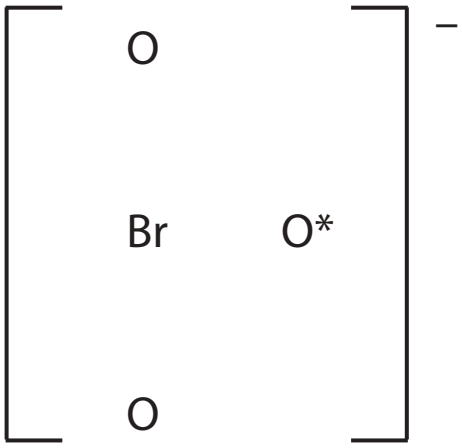
**19** Potassium bromate(V), $KBrO_3$, is a primary standard, meaning that it can be obtained as a pure substance and used to accurately determine the concentrations of solutions of other chemicals, such as sodium thiosulfate, $Na_2S_2O_3$.

(a) (i) Complete the dot and cross diagram for the bromate(V) ion. Show only the outer shell electrons.

In this ion, the bromine expands its outer shell to accommodate 12 electrons.

Use **x** for bromine electrons and • for oxygen electrons. The symbol * on the diagram represents the extra electron which gives the ion its charge.

**(2)**




(ii) Suggest how elements in Period 3 and higher can accommodate more than eight electrons in their outer shell.

**(1)**

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(b) Four chemistry students were given a solution of sodium thiosulfate with a concentration of **approximately** 0.1 mol $dm^{-3}$ and asked to determine its **exact** concentration.

They were each given separate tasks to carry out, as described below.

(i) The first student was given the task of making up a potassium bromate(V) solution. A mass of 8.35 g of $KBrO_3$ was weighed out, dissolved in deionized water, the volume made up to 250 $cm^3$ in a volumetric flask and the mixture shaken.

Calculate the concentration of this potassium bromate(V) solution, in mol $dm^{-3}$.

**(2)**

(ii) The second student was asked to determine a suitable mass of potassium iodide to add to 0.0025 mol of potassium bromate(V) to ensure complete reaction. The equation for the reaction is

$$BrO_3^-(aq) + 6H^+(aq) + 6I^-(aq) \rightarrow Br^-(aq) + 3I_2(aq) + 3H_2O(l)$$

Calculate the minimum mass of potassium iodide, KI, required and hence suggest a suitable mass to use if the potassium iodide is to be in excess.

You **must** show your working and your mass should be reasonable.

**(3)**

Minimum mass required ..... g

Suitable mass to use ..... g

(iii) The third student was given the following equation.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

This student was asked to estimate the titration reading.

Calculate the volume of 0.1 mol $dm^{-3}$ of sodium thiosulfate solution, in $cm^3$, that would be needed to react with 0.00100 mol of iodine present in the conical flask.

**(2)**

(iv) The fourth student carried out an alternative method for determining the concentration of the sodium thiosulfate solution. A known mass of solid potassium bromate(V) was dissolved in water in a conical flask. An excess of potassium iodide and acid were added and the mixture titrated with the sodium thiosulfate solution. The following measurements were obtained.

| | |
|---|---|
| Mass of $KBrO_3$ | 0.07 g |
| Volume of water | 25 $cm^3$ |
| Volume of $Na_2S_2O_3(aq)$ | 26.85 $cm^3$ |

The student calculated the concentration of the sodium thiosulfate, $Na_2S_2O_3$, to be 0.0937 mol $dm^{-3}$.

There is uncertainty in the value of the calculated concentration of the sodium thiosulfate. Which measurement, given in the table, has the greatest effect on the uncertainty of this value? Justify your answer.

No calculation is required for this answer.

**(2)**

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**(Total for Question 19 = 12 marks)**

**20** This question is about Group 2 elements and their compounds.

*(a) Give **two** reasons why the first ionization energy of calcium is less than that of magnesium, even though the atomic number of calcium is greater than that of magnesium.

**(2)**

(b) A flame test was carried out on a solid calcium compound. Explain the origin of the flame colour in terms of electron movement.

**(3)**

(c) (i) Calcium oxide reacts with dilute nitric acid to form calcium nitrate. Write the equation for this reaction. State symbols are not required.

**(1)**

(ii) Identify **two** ways, one of which should be an observation, in which the thermal decomposition of anhydrous calcium nitrate is different from that of anhydrous potassium nitrate.

**(2)**

(d) (i) Calcium reacts with water to produce calcium hydroxide and a gas. Give the name or formula of this gas.

**(1)**

.....

(ii) An aqueous solution of calcium hydroxide is used for a common laboratory test. Give the observation for a positive result for this test and complete the equation for the reaction that occurs. State symbols are **not** required.

**(2)**

Observation .....

$Ca(OH)_2$ + ..... → ..... + $H_2O$

(iii) Give the name or formula of a Group 2 hydroxide which is more soluble than calcium hydroxide.

**(1)**

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(e) (i) Describe what you would see if a solution of barium chloride was added to dilute sulfuric acid. State why this observation would differ if magnesium chloride solution was used instead of barium chloride.

**(2)**

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(ii) Barium compounds are toxic. However, it is safe to give patients a 'barium meal' of barium sulfate when trying to diagnose intestinal disorders. Suggest why this is so.

**(1)**

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*(f) Calcium carbonate, $CaCO_3$, readily reacts with hydrochloric acid. State **two** factors, other than a change in temperature, which would affect the rate of this reaction.

Neither pressure nor the use of a catalyst should be considered.

Explain how each of the **two** factors you have chosen alters the reaction rate.

**(4)**

(g) Suggest why pressure has little or no effect on the rate of the reaction of calcium oxide and hydrochloric acid, the equation for which is given below.

$$CaO(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l)$$

**(1)**

**(Total for Question 20 = 20 marks)**

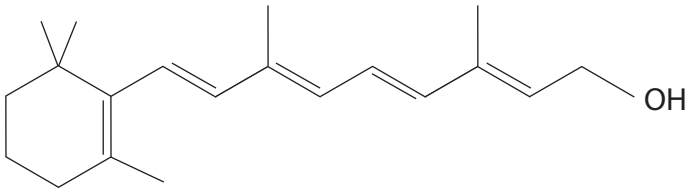
**TOTAL FOR SECTION B = 38 MARKS**

## SECTION C

**Answer ALL the questions. Write your answers in the spaces provided.**

**21** In the human body, one chemical can have a number of different effects.

An example is retinol, one of the substances in vitamin A.
The structure of retinol is shown below.




Retinol can be converted into retinal and a form of this is combined with an opsin molecule in the retina of the eye to make the light-sensitive pigment rhodopsin. When light enters the eye, the shape of the retinal molecule is changed, which results in it separating from the opsin molecule. The outcome of this separation is that we 'see' light.

Retinol can also be converted to retinoic acid, which is important in the body for the correct maintenance of mucous membranes. Failure to produce retinoic acid can lead to a condition known as 'dry eye', or xerophthalmia, which can result in blindness.

The functions of this vitamin, and other nutrient molecules, illustrate the need for a healthy, balanced diet.

(a) Retinol has an alcohol functional group. Classify the type of alcohol group in retinol and explain the meaning of the term 'functional group'.

**(2)**

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(b) Give the molecular formula of retinol.

**(2)**

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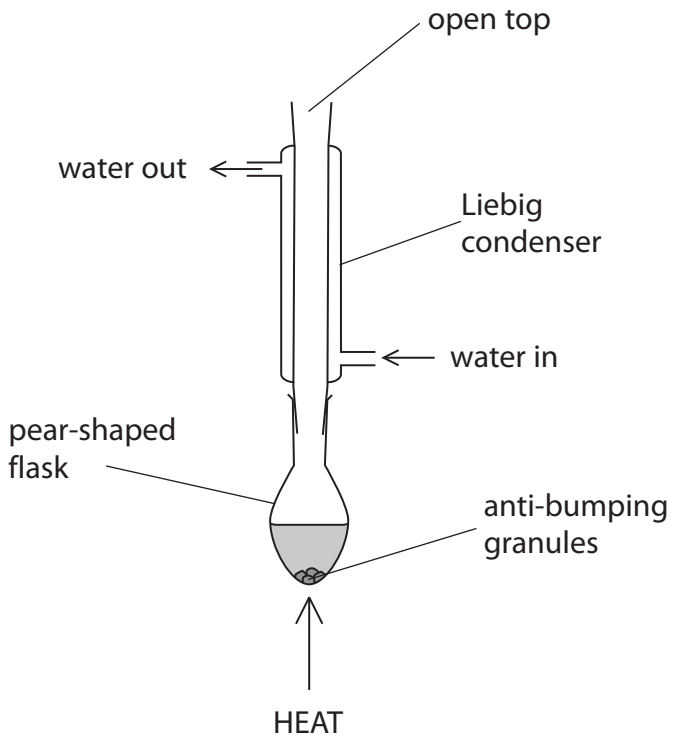
(c) Retinol can be oxidized to the aldehyde, retinal.

*(i) To illustrate the conversion of an alcohol to an aldehyde in the laboratory, a student suggested using the following apparatus and an excess of an oxidizing agent. Explain why this proposed method would have been unsuitable for the production of an aldehyde and explain what modifications are necessary for successful conversion. A new diagram is not required.

**(3)**

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(ii) The oxidizing agent suggested was sodium dichromate, $Na_2Cr_2O_7$, in acidic solution. Complete the ionic half-equation below. Give the oxidation numbers of the chromium in the chromium species and state their colours.

**(5)**

$Cr_2O_7^{2-}(aq)$ + .....$H^+(aq)$ + .....$e^-$ → .....$Cr^{3+}(aq)$ + .....$H_2O(l)$

Oxidation Number ..... .....

Colour ..... .....

*(iii) Describe **two** features on the infrared spectrum which could be used to determine whether the retinol has been completely converted to retinal.

Select some of the following infrared data to support your answer.

**(2)**

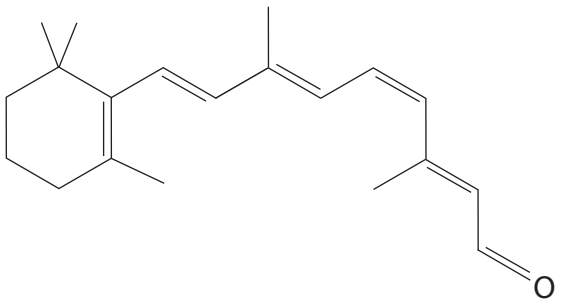
| | |
|---|---|
| O—H stretching in alcohols (variable, broad) at | 3750 – 3200 $cm^{-1}$ |
| O—H stretching in carboxylic acids (weak) at | 3300 – 2500 $cm^{-1}$ |
| C═O stretching in aldehydes (strong) at | 1740 – 1720 $cm^{-1}$ |
| C═O stretching in ketones (strong) at | 1700 – 1680 $cm^{-1}$ |
| C═O stretching in carboxylic acids, alkyl (strong) at | 1725 – 1700 $cm^{-1}$ |
| C—H stretching in aldehydes (weak) at | 2900 – 2820 $cm^{-1}$ |
| C—H stretching in aldehydes (weak) at | 2775 – 2700 $cm^{-1}$ |

(iv) The structure of the retinal molecule that combines with opsin in the human body differs from the structure expected from the oxidation of retinol.

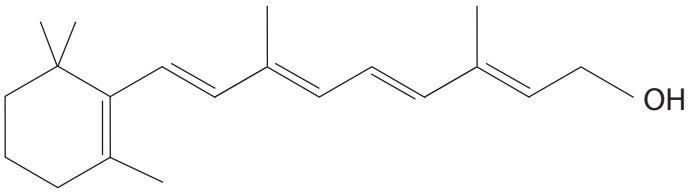
The structures of retinal and retinol are shown below.

**(1)**

Retinal




Retinol




As well as an oxidation, a structural change has occurred within the molecule. Circle only the part of the **retinal** molecule where this change has occurred.

(v) The bond angle around each carbon atom in a carbon-carbon double bond is about 120°. Explain the reason for this bond angle and state the name of the shape around each carbon atom.

**(3)**

Reason .....

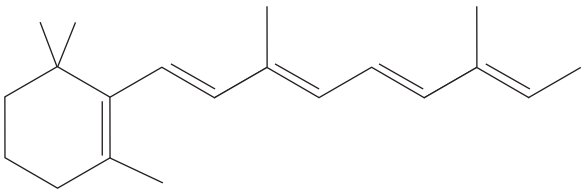
.....

.....

Shape .....

(d) Complete the diagram below to show the skeletal formula of retinoic acid.

**(1)**



*(e) Retinoic acid and retinol both have OH groups. Suggest **one** chemical reagent that you could use to test for the presence of an OH group which would work for both compounds. You may assume that both organic compounds are dissolved in suitable solvents.

Give the positive observation for the test and state **one** necessary experimental precaution that you would make to reduce the risk from carrying out this test.

**(3)**

Reagent .....

Observation .....

.....

.....

Precaution .....

.....

.....

.....

**(Total for Question 21 = 22 marks)**

**TOTAL FOR SECTION C = 22 MARKS**
**TOTAL FOR PAPER = 80 MARKS**

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# The Periodic Table of Elements

| 1 | 2 | | | | | | | | | | | 3 | 4 | 5 | 6 | 7 | 0 (8) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | | | | (18) |
| | | | | | | | 1.0 H hydrogen 1 | | | | | | | | | | 4.0 He helium 2 |
| (1) | (2) | | Key | | | | | | | | | (13) | (14) | (15) | (16) | (17) | |
| 6.9 Li lithium 3 | 9.0 Be beryllium 4 | | relative atomic mass<br>atomic symbol<br>name<br>atomic (proton) number | | | | | | | | | 10.8 B boron 5 | 12.0 C carbon 6 | 14.0 N nitrogen 7 | 16.0 O oxygen 8 | 19.0 F fluorine 9 | 20.2 Ne neon 10 |
| 23.0 Na sodium 11 | 24.3 Mg magnesium 12 | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | 27.0 Al aluminium 13 | 28.1 Si silicon 14 | 31.0 P phosphorus 15 | 32.1 S sulfur 16 | 35.5 Cl chlorine 17 | 39.9 Ar argon 18 |
| 39.1 K potassium 19 | 40.1 Ca calcium 20 | 45.0 Sc scandium 21 | 47.9 Ti titanium 22 | 50.9 V vanadium 23 | 52.0 Cr chromium 24 | 54.9 Mn manganese 25 | 55.8 Fe iron 26 | 58.9 Co cobalt 27 | 58.7 Ni nickel 28 | 63.5 Cu copper 29 | 65.4 Zn zinc 30 | 69.7 Ga gallium 31 | 72.6 Ge germanium 32 | 74.9 As arsenic 33 | 79.0 Se selenium 34 | 79.9 Br bromine 35 | 83.8 Kr krypton 36 |
| 85.5 Rb rubidium 37 | 87.6 Sr strontium 38 | 88.9 Y yttrium 39 | 91.2 Zr zirconium 40 | 92.9 Nb niobium 41 | 95.9 Mo molybdenum 42 | [98] Tc technetium 43 | 101.1 Ru ruthenium 44 | 102.9 Rh rhodium 45 | 106.4 Pd palladium 46 | 107.9 Ag silver 47 | 112.4 Cd cadmium 48 | 114.8 In indium 49 | 118.7 Sn tin 50 | 121.8 Sb antimony 51 | 127.6 Te tellurium 52 | 126.9 I iodine 53 | 131.3 Xe xenon 54 |
| 132.9 Cs caesium 55 | 137.3 Ba barium 56 | 138.9 La* lanthanum 57 | 178.5 Hf hafnium 72 | 180.9 Ta tantalum 73 | 183.8 W tungsten 74 | 186.2 Re rhenium 75 | 190.2 Os osmium 76 | 192.2 Ir iridium 77 | 195.1 Pt platinum 78 | 197.0 Au gold 79 | 200.6 Hg mercury 80 | 204.4 Tl thallium 81 | 207.2 Pb lead 82 | 209.0 Bi bismuth 83 | [209] Po polonium 84 | [210] At astatine 85 | [222] Rn radon 86 |
| [223] Fr francium 87 | [226] Ra radium 88 | [227] Ac* actinium 89 | [261] Rf rutherfordium 104 | [262] Db dubnium 105 | [266] Sg seaborgium 106 | [264] Bh bohrium 107 | [277] Hs hassium 108 | [268] Mt meitnerium 109 | [271] Ds darmstadtium 110 | [272] Rg roentgenium 111 | | | | | | | |

Elements with atomic numbers 112-116 have been reported but not fully authenticated

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 140 Ce cerium 58 | 141 Pr praseodymium 59 | 144 Nd neodymium 60 | [147] Pm promethium 61 | 150 Sm samarium 62 | 152 Eu europium 63 | 157 Gd gadolinium 64 | 159 Tb terbium 65 | 163 Dy dysprosium 66 | 165 Ho holmium 67 | 167 Er erbium 68 | 169 Tm thulium 69 | 173 Yb ytterbium 70 | 175 Lu lutetium 71 |
| 232 Th thorium 90 | [231] Pa protactinium 91 | 238 U uranium 92 | [237] Np neptunium 93 | [242] Pu plutonium 94 | [243] Am americium 95 | [247] Cm curium 96 | [245] Bk berkelium 97 | [251] Cf californium 98 | [254] Es einsteinium 99 | [253] Fm fermium 100 | [256] Md mendelevium 101 | [254] No nobelium 102 | [257] Lr lawrencium 103 |

* Lanthanide series

* Actinide series