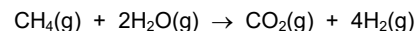


3 What contains 9.03×10^{23} oxygen atoms?

- A** 0.25 mol aluminium oxide
B 0.75 mol sulfur dioxide
C 1.5 mol sulfur trioxide
D 3.0 mol water

4 Methane and steam react to produce hydrogen.

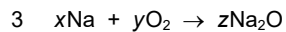
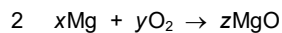
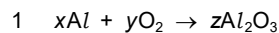


0.80 g of methane and 1.35 g of steam react. One of the reactants is used up.

Which volume of hydrogen, measured at room conditions, will be produced?

- A** 1.80 dm³ **B** 3.60 dm³ **C** 4.80 dm³ **D** 7.20 dm³

17 Three equations are listed. x , y and z are all whole numbers.



Which equations can be balanced if $x = 4$ and $z = 2$?

- A** 1 and 3 **B** 1 only **C** 2 only **D** 3 only

40 A sample of magnesium contains the isotopes ^{24}Mg , ^{25}Mg and ^{26}Mg only.

The percentage abundance of ^{25}Mg and ^{26}Mg is the same.

The relative atomic mass of magnesium in the sample is 24.3.

What is the percentage abundance of ^{24}Mg ?

- A** 10% **B** 20% **C** 60% **D** 80%

Important values, constants and standards

molar gas constant	$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$
Faraday constant	$F = 9.65 \times 10^4 \text{ C mol}^{-1}$
Avogadro constant	$L = 6.02 \times 10^{23} \text{ mol}^{-1}$
electronic charge	$e = -1.60 \times 10^{-19} \text{ C}$
molar volume of gas	$V_m = 22.4 \text{ dm}^3 \text{ mol}^{-1}$ at s.t.p. (101 kPa and 273 K) $V_m = 24.0 \text{ dm}^3 \text{ mol}^{-1}$ at room conditions
ionic product of water	$K_w = 1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$ (at 298 K (25 °C))
specific heat capacity of water	$c = 4.18 \text{ kJ kg}^{-1} \text{ K}^{-1}$ (4.18 J g ⁻¹ K ⁻¹)

The Periodic Table of Elements

Group																	
1	2															17	18
		Key															
		atomic number atomic symbol same relative atomic mass															
3	4																
Li lithium 6.9	Be beryllium 9.0															9	10
11	12															16	17
Na sodium 23.0	Mg magnesium 24.3															32.1	35.5
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K potassium 39.1	Ca calcium 40.1	Sc scandium 45.0	Ti titanium 47.9	V vanadium 50.9	Cr chromium 52.0	Mn manganese 54.9	Fe iron 55.8	Co cobalt 58.9	Ni nickel 58.7	Cu copper 63.5	Zn zinc 65.4	Ga gallium 69.7	Ge germanium 72.6	As arsenic 74.9	Se selenium 79.0	Br bromine 79.9	Kr krypton 83.8
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb rubidium 85.5	Sr strontium 87.6	Y yttrium 88.9	Zr zirconium 91.2	Nb niobium 92.9	Mo molybdenum 95.9	Tc technetium —	Ru ruthenium 101.1	Rh rhodium 102.9	Pd palladium 106.4	Ag silver 107.9	Cd cadmium 112.4	In indium 114.8	Sn tin 118.7	Sb antimony 121.8	Te tellurium 127.6	I iodine 126.9	Xe xenon 131.3
55	56	57–71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs caesium 132.9	Ba barium 137.3	lanthanoids					Os osmium 190.2	Ir iridium 192.2	Pt platinum 195.1	Au gold 197.0	Hg mercury 200.6	Tl thallium 204.4	Pb lead 207.2	Bi bismuth 209.0	Po polonium —	At astatine —	Rn radon —
87	88	89–103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
Fr francium —	Ra radium —	actinoids					Hs hassium —	Mt meitnerium —	Ds darmstadtium —	Rg roentgenium —	Cn copernicium —	Nh nihonium —	Fl flerovium —	Mc moscovium —	Lv livermorium —	Ts tennessine —	Og oganesson —

lanthanoids

actinoids

57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
La lanthanum 138.9	Ce cerium 140.1	Pr praseodymium 140.9	Nd neodymium 144.2	Pm promethium —	Sm samarium 150.4	Eu europium 152.0	Gd gadolinium 157.3	Tb terbium 158.9	Dy dysprosium 162.5	Ho holmium 164.9	Er erbium 167.3	Tm thulium 168.9	Yb ytterbium 173.1	Lu lutetium 175.0
89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
Ac actinium —	Th thorium 232.0	Pa protactinium 231.0	U uranium 238.0	Np neptunium —	Pu plutonium —	Am americium —	Cm curium —	Bk berkelium —	Cf californium —	Es einsteinium —	Fm fermium —	Md mendelevium —	No nobelium —	Lr lawrencium —

3 Cycloalkanes show similar chemical properties to alkanes but have the same empirical formula as alkenes.

(a) Define empirical formula.
.....
..... [1]

(b) Cyclopentane, C₅H₁₀, has four cyclic structural isomers. One of these isomers is C, shown in Fig. 3.1.

Complete Fig. 3.1 to show two other cyclic structural isomers of C₅H₁₀.

cyclopentane 			C 
---	--	--	--

Fig. 3.1 [2]

(c) Cyclopentane reacts with Cl₂ in the presence of ultraviolet light to form C₅H₉Cl.
(i) The reaction is initiated by the bond fission of Cl₂.

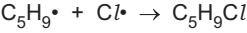
State the type of bond fission shown in the initiation step.
..... [1]

(ii) Complete the equations to show the two propagation steps that follow the initiation step.

propagation 1 C₅H₁₀ + → C₅H₉• +

propagation 2 C₅H₉• + → [2]

(iii) The final step is shown.



Give the name for this step in the reaction.
..... [1]

(d) Fig. 3.2 shows a reaction cycle involving cyclopentane, cyclopentene and C_5H_9Cl .

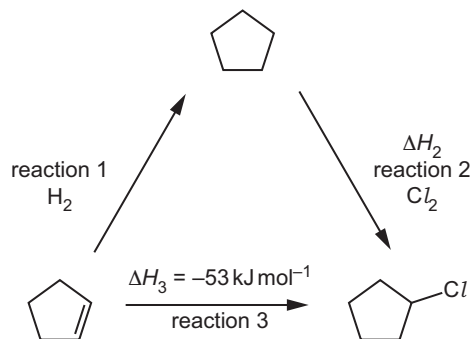


Fig. 3.2

(i) Identify a suitable reagent for reaction 3.

..... [1]

(ii) Use the data in Fig. 3.2 and in Table 3.1 to calculate the enthalpy change of reaction 2, ΔH_2 .

Table 3.1

compound	enthalpy change of combustion, $\Delta H_c / \text{kJ mol}^{-1}$
	-3292
	-3115
H_2	-286

⑤ $\Delta H_2 = \dots\dots\dots \text{kJ mol}^{-1}$ [2]

(e) Cyclopentene, C_5H_8 , reacts with hot concentrated acidified $KMnO_4$ to form compound **W**, $C_5H_8O_4$.

(i) Draw the structure of **W**.

[1]

(ii) The infrared spectrum of **W** is shown in Fig. 3.3.

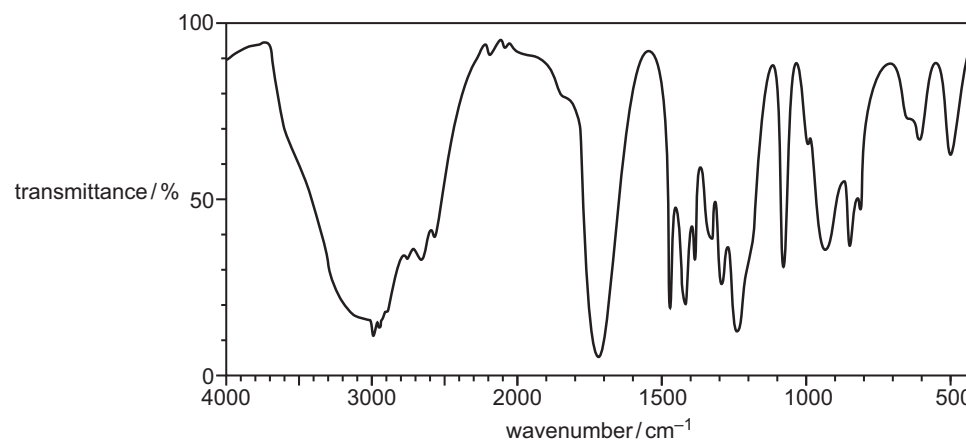


Fig. 3.3

Identify **two** absorptions in the infrared spectrum of **W** that would **not** be present in the infrared spectrum of cyclopentene.

- Write **1** or **2** on Fig. 3.3 against each of these two absorptions.
- Complete Table 3.2 to show which bond is responsible for each absorption that you have identified in Fig. 3.3.

Table 3.2

absorption	1	2
bond responsible		

[2]

⑥

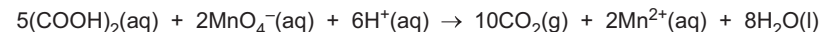
Table 3.3

bond	functional groups containing the bond	characteristic infrared absorption range (in wavenumbers)/cm ⁻¹
C–O	hydroxy, ester	1040–1300
C=C	aromatic compound, alkene	1500–1680
C=O	amide carbonyl, carboxyl ester	1640–1690 1670–1740 1710–1750
C≡N	nitrile	2200–2250
C–H	alkane	2850–2950
N–H	amine, amide	3300–3500
O–H	carboxyl hydroxy	2500–3000 3200–3650

[Total: 13]

1 Hydrated ethanedioic acid is a diprotic acid with the formula (COOH)₂•xH₂O where x is an integer.

Ethanedioic acid reacts with manganate(VII) ions when heated.



You will determine the value of x in (COOH)₂•xH₂O by titrating a solution containing ethanedioic acid with manganate(VII) ions.

- **FA 1** is 6.20 g dm⁻³ aqueous ethanedioic acid, (COOH)₂•xH₂O.
- **FA 2** is 0.0200 mol dm⁻³ potassium manganate(VII), KMnO₄.
- **FA 3** is 1.0 mol dm⁻³ sulfuric acid, H₂SO₄.

(a) **Method**

- Fill the burette with **FA 2**.
- Pipette 25.0 cm³ of **FA 1** into a conical flask.
- Use the measuring cylinder to add approximately 20 cm³ of **FA 3** to the conical flask.
- Place the conical flask on a tripod and gauze and heat carefully until the temperature of the solution is approximately 70 °C.
- Remove the flame.
- Carefully lift the hot conical flask and place it on the white tile under the burette.
- Add **FA 2** drop-wise for the first 2–3 cm³. Any initial pink colouring may take several seconds to disappear.
- If the reaction mixture turns brown, reheat it to about 70 °C. If the brown colour disappears, continue the titration. If the brown colour remains, discard the contents of the flask and begin a new titration.
- The end-point is reached when a permanent pale pink colour is formed.
- Perform a rough titration with **FA 2**. Record your burette readings in the space below.

The rough titre is cm³.

- Carry out as many titrations as you think necessary to obtain consistent results.
- Make sure any recorded results show the precision of your practical work.
- Record all your burette readings and the volume of **FA 2** added in each accurate titration.

Results

I	
II	
III	
IV	
V	
VI	
VII	

[7]

- (b) From your accurate titration results, calculate a suitable mean value to be used in your calculations.

Show clearly how you obtained this value.

25.0 cm³ of **FA 1** required cm³ of **FA 2**. [1]

(c) Calculations

- (i) Give your answers to (c)(ii), (c)(iii) and (c)(iv) to the appropriate number of significant figures. [1]

- (ii) Calculate the amount, in mol, of manganate(VII) ions, MnO_4^- , in the volume of **FA 2** calculated in (b).

amount of MnO_4^- = mol [1]

- (iii) Calculate the amount, in mol, of ethanedioic acid that reacts with the manganate(VII) ions in (c)(ii).

amount of $(\text{COOH})_2$ = mol

Hence calculate the concentration, in mol dm⁻³, of ethanedioic acid in **FA 1**.

concentration of $(\text{COOH})_2$ = mol dm⁻³ [2]

- (iv) Calculate the relative molecular mass, M_r , of the ethanedioic acid in **FA 1**.

M_r = [1]

- (v) Calculate the value of **x** in $(\text{COOH})_2 \cdot x\text{H}_2\text{O}$.

Show your working.

x = [1]

- (d) Explain why it is necessary to add **FA 3** in each titration.

.....
..... [1]

[Total: 15]