Past-paper walk-through

Alkenes ▪ 14.2

eXercise

Questions in this set

- 9701/11 N25 Q27 ▪ 1 mark
- 9701/12 N25 Q27 ▪ 1 mark
- 9701/12 N25 Q28 ▪ 1 mark
- 9701/12 N25 Q29 ▪ 1 mark
- 9701/14 N25 Q29 ▪ 1 mark
- 9701/21 N25 Q4 ▪ 15 marks

Reading the mark scheme

- **B1** a mark that stands on its own – the point is either made or not.
- **M1** a *method* mark: the right approach, even if the number is wrong.
- **A1** an *answer* mark, and it usually needs its M mark first.
- **C1** a working mark on the way to the answer.
- // separates answers the examiner accepts equally.
- **ecf** = error carried forward: a later part is marked on your own earlier answer.
- **owtte** = "or words to that effect" – the wording need not match.

Question 27

9701/11 N25 ▪ Q27 ▪ 1 mark

27 Which intermediate ion forms in the greatest amount during the addition of HBr to propene?

A $CH_3CH^+CH_3$

B $CH_3CH_2CH_2^+$

C $CH_3CH^-CH_2Br$

D $CH_3CHBrCH_2^-$

Solution 27

Answer: **A**

Why

- H^+ adds so as to leave the more stable carbocation.
- On propene that is the *secondary* cation $CH_3CH^+CH_3$, stabilised by two alkyl groups.
- The primary cation is far less stable, so much less of it forms.

Question 27

9701/12 N25 ▪ Q27 ▪ 1 mark

27 What is the major product when 2-methylpent-2-ene reacts with hydrogen bromide?

A 1-bromo-2-methylpentane

B 2-bromo-2-methylpentane

C 3-bromo-2-methylpentane

D 4-bromo-2-methylpentane

Solution 27

Answer: **B**

Why

- Markovnikov: the bromine ends up on the carbon that gives the more stable carbocation.
- Adding H^+ to C3 leaves a *tertiary* cation at C2.
- Br^- then attacks there, giving 2-bromo-2-methylpentane.

Question 28

9701/12 N25 ▪ Q28 ▪ 1 mark

28 Pent-2-ene is reacted with cold, dilute, acidified manganate(VII) ions.

What is the major product?

A $CH_3CH_2CH(OH)CH(OH)CH_3$

B $CH_3CH_2COCOCH_3$

C a mixture of $CH_3CH_2CH(OH)CH_2CH_3$ and $CH_3CH_2CH_2CH(OH)CH_3$

D CH_3CH_2COOH and CH_3COOH

Solution 28

Answer: **A**

Why

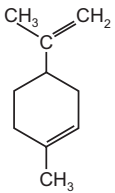
- Cold, dilute manganate(VII) adds two OH groups across the C=C.
- Pent-2-ene therefore gives the 2,3-diol.
- Hot concentrated conditions would break the C=C right open and give carboxylic acids instead.

Question 29

9701/12 N25 ▪ Q29 ▪ 1 mark

29 Limonene is an oil formed in the peel of citrus fruits.

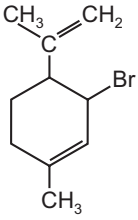
limonene

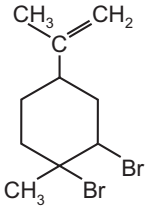


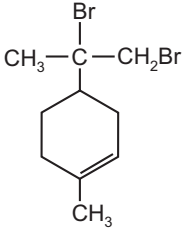
Which product is formed when an excess of bromine, $Br_2(l)$, reacts with limonene at room temperature in the dark?

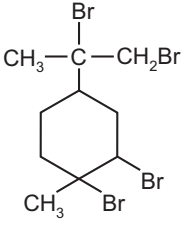
A **B** **C** **D**

Question 29


CH3
CH2
C
Br
CH3


CH3
CH2
C
Br
CH3
Br


Br
CH3
C
CH2Br
CH3


Br
CH3
C
CH2Br
Br
CH3
Br

Solution 29

Answer: **D**

Why

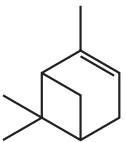
- In the dark there is no free-radical substitution, so bromine simply adds across C=C.
- Limonene has two C=C bonds, one in the ring and one in the side chain.
- With bromine in excess both add, so four bromine atoms are taken up.

Question 29

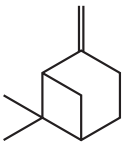
9701/14 N25 ▪ Q29 ▪ 1 mark

29 Pinenes are unsaturated compounds. The structures of two pinenes are shown.

α-pinene



β-pinene



A mixture of these two pinenes reacts with hot concentrated acidified $KMnO_4$.

What are the molecular formulae of the organic products?

Question 29

A $C_9H_{14}O$ and $C_{10}H_{16}O_3$

B $C_9H_{14}O$ and $C_{10}H_{14}O_4$

C $C_9H_{16}O_2$ and $C_{10}H_{16}O_3$

D $C_9H_{16}O_2$ and $C_{10}H_{14}O_4$

Solution 29

Answer: **A**

Why

- Hot concentrated manganate(VII) cleaves each C=C completely.
- A carbon of the C=C that carries an alkyl group becomes a ketone; one carrying a hydrogen becomes a carboxylic acid.
- The two pinenes have their double bonds in different places, so their products have different formulae.

Question 4

9701/21 N25 ▪ Q4 ▪ 15 marks

4 Fig. 4.1 shows a possible synthesis of propene, C_3H_6.

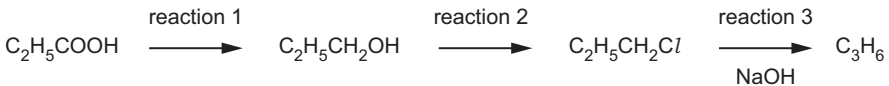


Fig. 4.1

(a) (i) Identify the type of reaction that occurs in reaction 1.

Question 4

(ii) Suggest a suitable reagent for reaction 2.

Question 4

(iii) Reaction 3 is an elimination reaction.

Write an equation for this reaction and identify the solvent and conditions used.

Question 4

Question 4

[2]

(iv) $C_2H_5CH_2OH$ can be directly converted to C_3H_6.

Suggest the reagent and conditions for this conversion.

Question 4

(b) Under suitable conditions, propene polymerises to form poly(propene).

Poly(propene) exhibits stereoisomerism.

(i) Identify the type of polymerisation that forms poly(propene) from propene.

Question 4

(ii) Define stereoisomerism.

Question 4

(iii) Draw a section of poly(propene), showing **two** repeat units.

Use your diagram to identify the type of stereoisomerism shown by poly(propene). Explain your answer.

section of poly(propene)

Question 4

[3]

(iv) State **two** difficulties associated with the disposal of poly(propene).

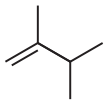
Question 4

Question 4

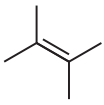
[2]

(c) Under different conditions, two molecules of propene can combine to form compounds **X** and **Y**.

X



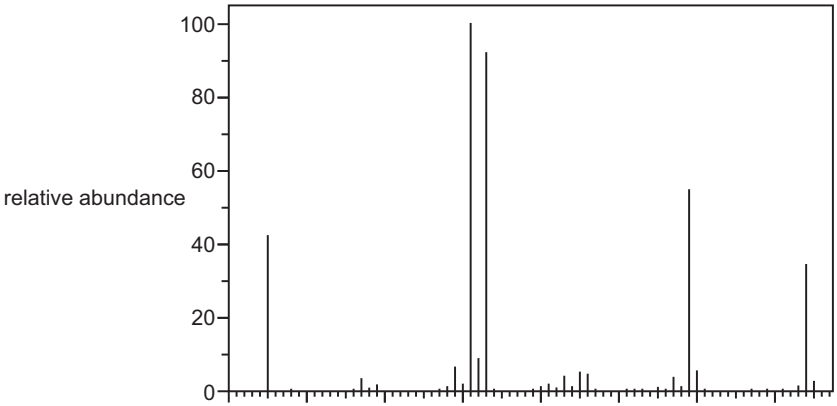
Y



(i) Name **X**.

Question 4

(ii) Fig. 4.2 shows the mass spectrum of either compound **X** or compound **Y**.



Question 4

10 20 30 40 50 60 70 80

Question 4

Fig. 4.2

Identify which of **X** and **Y** gives this mass spectrum.

Give **one** reason for your answer, referring to the fragmentation pattern.

Question 4

(iii) The molecular ion peak in the spectrum in Fig. 4.2 has relative abundance 34.7.

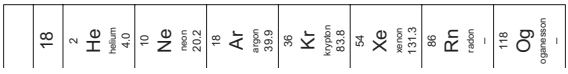
Calculate the relative abundance of the $[M+1]^+$ peak in this spectrum.

Question 4

[Total: 16]

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	$c = 4.18\,\text{kJ kg}^{-1}\,\text{K}^{-1}$ ($4.18\,\text{J g}^{-1}\,\text{K}^{-1}$)



nts

		13	14	15	16	17
		5 B boron 10.8	6 C carbon 12.0	7 N nitrogen 14.0	8 O oxygen 16.0	9 F fluorine 19.0
1	12	13 Al aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 Cl chlorine 35.5
9 u per .5	30 Zn zinc 65.4	31 Ga gallium 69.7	32 Ge germanium 72.6	33 As arsenic 74.9	34 Se selenium 79.0	35 Br bromine 79.9
7 g er 7.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn tin 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9
9 u id 7.0	80 Hg mercury 200.6	81 Tl thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium –	85 At astatine –
1 g enium ·	112 Cn copernicium –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –

5 b ium 3.9	66 Dy dysprosium 162.5	67 Ho holmium 164.9	68 Er erbium 167.3	69 Tm thulium 168.9	70 Yb ytterbium 173.1	71 Lu lutetium 175.0
7 k lium ·	98 Cf californium –	99 Es einsteinium –	100 Fm fermium –	101 Md mendelevium –	102 No nobelium –	103 Lr lawrencium –

The Periodic Table of Elemer

Group

1
H
hydrogen
1.0

Key

atomic number
omic symbol
name
lative atomic mass

5	6	7	8	9	10	1
23	24	25	26	27	28	2
V	Cr	Mn	Fe	Co	Ni	C
vanadium	chromium	manganese	iron	cobalt	nickel	copp
50.9	52.0	54.9	55.8	58.9	58.7	63
41	42	43	44	45	46	4
Nb	Mo	Tc	Ru	Rh	Pd	A
niobium	molybdenum	technetium	ruthenium	rhodium	palladium	silv
92.9	95.9	–	101.1	102.9	106.4	107
73	74	75	76	77	78	7
Ta	W	Re	Os	Ir	Pt	A
tantalum	tungsten	rhenium	osmium	iridium	platinum	gol
180.9	183.8	186.2	190.2	192.2	195.1	197
105	106	107	108	109	110	11
Db	Sg	Bh	Hs	Mt	Ds	R
dubnium	seaborgium	bohrium	hassium	meitnerium	darmstadtium	roentge
–	–	–	–	–	–	–

59	60	61	62	63	64	6
Pr	Nd	Pm	Sm	Eu	Gd	T
praseodymium	neodymium	promethium	samarium	europium	gadolinium	terbi
140.9	144.2	–	150.4	152.0	157.3	15
91	92	93	94	95	96	9
Pa	U	Np	Pu	Am	Cm	B
protactinium	uranium	neptunium	plutonium	americium	curium	berke
231.0	238.0	–	–	–	–	–

1	2		
3 Li lithium 6.9	4 Be beryllium 9.0		at rei
11 Na sodium 23.0	12 Mg magnesium 24.3	3	4
19 K potassium 39.1	20 Ca calcium 40.1	21 Sc scandium 45.0	22 Ti titanium 47.9
37 Rb rubidium 85.5	38 Sr strontium 87.6	39 Y yttrium 88.9	40 Zr zirconium 91.2
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 lanthanoids	72 Hf hafnium 178.5
87 Fr francium –	88 Ra radium –	89–103 actinoids	104 Rf rutherfordium –

lanthanoids	57 La lanthanum 138.9	58 Ce cerium 140.1
actinoids	89 Ac actinium –	90 Th thorium 232.0

Solution 4

(a)(i)

Mark scheme

- reduction
- 1

Solution 4

(a)(ii)

Mark scheme

- PCl5 / PCl3 / SOCl2
- OR KCl / NaCl AND conc. H2SO4 / conc.H3PO4
- 1 M1
- C2H5CH2Cl + NaOH → C3H6 + H2O + NaCl M2
- ethanol (solvent) AND heat / reflux
- 2

Solution 4

(a)(iv)

Mark scheme

- conc. H2SO4 OR conc. H3PO4 OR Al2O3 AND heat
- 1

Solution 4

(b)(i)

Mark scheme

- addition
- 1

Solution 4

(b)(ii)

Mark scheme

- M1 (molecules that have the) same structural formula (and same molecular formula) **M2**
- but different 3D / spatial arrangement of atoms / groups
- 2

Solution 4

(b)(iii)

Mark scheme

- M2 optical isomerism M3
- the methylated carbon has four different groups attached
- 3

Solution 4

(b)(iv)

Mark scheme

- M1 non-biodegradability M2
- harmful combustion products
- 2

Solution 4

(c)(i)

Mark scheme

- 2,3-dimethylbut-1-ene
- 1
- 9701/21
- October/November 2025

Solution 4

(c)(ii) Mark scheme

- (The spectrum is of) X
- AND
- 41 is [CH2=CCH3]+ / 41 is C3H5+
- OR 43 is [CH3CHCH3]+ / 43 is C3H7+
- OR X would NOT have significant peak at 54 / [(CH3)2C=C+] / C4H6+
- OR X would NOT have significant peak at 42 due to [(CH3)2C+] / C3H6+
- 1

Solution 4

(c)(iii)

Mark scheme

- ([M+1]+ / 34.7 × 100 / 1.1 = 6)

M+1 + = 2.29

- 1