M1.(a) (i) C_4H_{10}

M_r = 4(12.00000) + 10(1.00794)

= <u>58.07940</u> or <u>58.0794</u> or <u>58.079</u> or <u>58.08</u>

<u>and</u> **<u>58.1</u>**

Working is essential, leading to the final value of 58.1 which must be stated in addition to one of the four numbers underlined

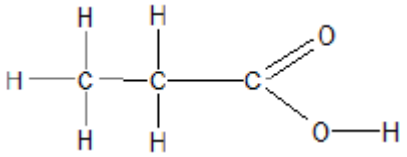
1

(ii) <u>By definition</u>
OR
The <u>standard</u> / <u>reference</u> (value / isotope)

Reference to ^{12}C alone is not enough

1

(b)



All bonds and atoms must be drawn
Give credit for the displayed formula for the anion

1

(c) (i) $H_2C = CHCH_2OH$

Any correct representation including correct use of "sticks".
Require the double bond to be shown

1

(ii) <u>Addition</u> (polymerisation)

ONLY this answer

1

(iii) **M1** **<u>C = C</u>** (in range) **<u>1620 to 1680</u>** (cm^{-1})

M2 **<u>O – H</u>** (in range) **<u>3230 to 3550</u>** (cm^{-1})

Award one mark for two correct ranges but a failure to draw out the C = C or O–H bonds

2

(d) (i) CH_3COCH_3

Any correct representation including correct use of "sticks"

1

(ii) C

1

[9]

M2. (a) **2**$Ca_5F(PO_4)_3$ + $9SiO_2$ + **15**C ⟶ $9CaSiO_3$ + CaF_2 + **15**CO + **6**P

1

(b) **M1** (P_4 =) **0**

M2 (H_3PO_4 =) **(+) 5**

*Accept Roman numeral V for **M2***

2

(c) H_2SO_4

***Both numbers** required*

M_r = 2(1.00794) + 32.06550 + 4(15.99491)
= **98.06102 or 98.0610 or 98.061 or 98.06 or 98.1**

Calculations not required

<u>and</u>

H_3PO_4

M_r = 3(1.00794) + 30.97376 + 4(15.99491)
= **97.97722 or 97.9772 or 97.977 or 97.98 or 98.0**

1

(d) (i) A substance that <u>speeds up</u> a reaction OR <u>alters / increases the rate</u> of a reaction **AND** is <u>chemically unchanged at the end / not used up</u>.

***Both ideas** needed*

Ignore reference to activation energy or alternative route.

1

(ii) The addition of water (**QoL**) to a molecule / compound

QoL- for the underlined words

1

(iii) **M1** $CH_3CH=CH_2 + H_2O \longrightarrow CH_3CH(OH)CH_3$

(C_3H_6)

*For **M1** insist on correct structure for the alcohol but credit correct equations using either C_3H_6 or double bond not given.*

M2 propan-2-ol

2

[8]

M3.(a) H ***OR*** hydrogen ***OR*** $H^{\bullet}$

Ignore brackets ignore dot

penalise + or – charge

1

(b) CH_3 ***OR*** methyl ***OR*** $CH_3^{\bullet}$ ***OR*** $^{\bullet}CH_3$

Ignore brackets ignore dot

penalise + or – charge

1

(c) Either order

C_2H_5 ***OR*** ethyl ***OR*** $CH_3CH_2^{\bullet}$ ***OR*** $C_2H_5^{\bullet}$

Ignore brackets ignore dot

penalise + or – charge

1

CHO ***OR*** HCO ***OR*** COH ***OR*** H—C=O

1

(d) I A

1

II C

1

III D

1

IV B

1

[8]

M4. (a) The molecular ion is

- The molecule with one/an electron knocked off/lost
  Ignore the highest or biggest m/z peak

OR

- The molecule with a (single) positive charge

OR

- the ion with/it has the largest/highest/biggest m/z (value/ratio)
  Ignore "the peak to the right"

OR

- the ion with/it has an m/z equal to the M_r
  Ignore "compound"

1

(b) (i) 2(14.00307) + 15.99491 = 44.00105
A sum is needed to show this

1

(ii) Propane/C_3H_8 and carbon dioxide/CO_2 (and N_2O) or
they or both the gases/molecules or all three gases/molecules
have an (imprecise) M_r of 44.0 (OR 44)

OR

they have the same M_r or molecular mass (to one d.p)

This could be shown in a calculation of relative masses for propane and carbon dioxide

1

(iii) By definition

OR

The standard/reference (value/isotope)

Ignore "element"

Ignore "atom"

1

(c) (i) **M1 (could be scored by a correct mathematical expression)**

$\Delta H = \Sigma\Delta H_{products} - \Sigma\Delta H_{reactants}$

OR a correct cycle of balanced equations

M1 and M2 can be scored with correct moles as follows
$\Delta H + 2(-46) = +82 + 3(-286)$

$\Delta H - 92 = -776$

$\Delta H = 92 - 776$ OR $92 + 82 - 858$

M3
$\Delta H = -684$ (kJ mol^{-1}) (This is worth 3 marks)

Award 1 mark ONLY for + 684

Full marks for correct answer.

Ignore units.

Deduct one mark for an arithmetic error.

3

(ii) The value is quoted at a pressure of 100 kPa OR 1 bar or 10^5 Pa

OR

All reactants and products are in their standard states/their normal states at 100 kPa or 1 bar

Ignore 1 atmosphere/101 kPa

Ignore "constant pressure"

1

[8]