Q1.

2 (a) $2Ca(NO_3)_2 \longrightarrow 2CaO + 4NO_2 + O_2$ (*or* x ½) [1] **[1]**

(b) more stable down the group (*or* higher temperature needed) [1]
(cat)**ionic** size/radius increases down the group
(*or* **ionic** charge density decreases) [1]
distortion/polarisation of anion/nitrate (ion) decreases [1] **[3]**

(c) (i) $16 = O^+$ $17 = OH^+$ $18 = H_2O^+$ *(ignore charges)* all 3 [1]
$14 = N^+$ $16 = O^+$ $28 = N_2^+$ $30 = NO^+$ $44 = N_2O^+$ all 5 [3]
any 4 *[2]*
(ignore charges) *any 3* *[1]*
$\therefore$ **A** = H_2O **and** **B** = N_2O (or in equation below) [1]

(ii) $NH_4NO_3 \longrightarrow N_2O + 2H_2O$ [1] **[6]**

[Total: 10 max. 9]

Q2.

9 **(a) (i)+(ii)** any two of:
molecular mass/size/M_r/shape
(overall electrical) charge (on the species)
voltage/size/P.D. (of applied electric field) [1] + [1]
(salvage: if just "mass & charge" is mentioned, with no reference to species or molecule, award [1])

[2]

(b) (i) CH_3COCH_3 would show
a single peak/no splitting since all the Hs are in the same chemical environment
or a peak at $\delta = 2.1$ due to CH_3CO group [1]

CH_3CH_2CHO would show 3 (sets of) peaks since there are 3 different proton environments
or there would be a peak at $\delta = 9.5 - 10.0$ due to the –CHO group
or a peak at $\delta = 0.9$ due to CH_3
or a peak at $\delta 1.3$ due to CH_2 [1]

(reasons needed for the marks. Salvage: if reasons are not given, but candidate states that propanone will have one peak and propanal three, then award [1] mark)

(ii) different fragments:

- CH_3COCH_3 would form **fewer** fragments (must be stated in words)
- CH_3COCH_3 would form a fragment of CH_3CO^+ *or* at (m/e) 43
- CH_3CH_2CHO would form a fragment of $CH_3CH_2^+$ *or* CHO^+ at (m/e) 29
- CH_3CH_2CHO would form a fragment of $CH_3CH_2CO^+$ *or* at (m/e) 57

[charges on fragments not required for mark]

any 3 points [3]

[5]

(c) (i) peaks at (m/e) 79 **and** 81 *or* at (m/e) 94 **and** 96 [1]

(ii) in chlorine the M and M+2 peaks are the ratio 3:1 [1]
whereas in bromine they are approx. 1:1 [1] **[3]**

[Total: 10 max 9]

Q3.

8 **(a)** **(i)** Partition coefficient (PC) is an equilibrium constant representing the distribution of a solute between two solvents.
or PC = ratio of the concentrations of the solute in the two solvents *or* $PC = [X]_a/[X]_b$ [1]

(ii) If 0.4 g has been extracted, 0.1 g remain in the aqueous layer.

the concentration in the hexane layer = $\frac{0.4}{20} = 0.02\,g\ cm^{-3}$

the concentration in the aqueous layer = $\frac{0.1}{100} = 0.001\,g\ cm^{-3}$

$K_{pc} = 0.02/0.001 =$ **20** [1]

(iii) *1st extraction*: hexane $x/10\ g\ cm^{-3}$ water $(0.50-x)/100\ g\ cm^{-3}$

$K_{pc} = \frac{x/10}{(0.5-x)/100} = 20$

hence $x/10 = (10 - 20x)/100$

$100x = 10(10 - 20x)$ or $100x = 100 - 200x$

$x =$ **0.33 g** [1]

2nd extraction: hexane $y/10\ g\ cm^{-3}$ water $(0.17 - y)/100\ g\ cm^{-3}$

$K_{pc} = \frac{y/10}{(0.17-y)/100} = 20$

hence $y/10 = (3.4 - 20y)/100$

$100y = 10(3.4 - 20y)$ or $100y = 34 - 200y$

$y =$ **0.11 g** [1]

total extracted = **0.44** g, *or* difference = **0.04** g *or* **10% more** (is extracted) [1]
(correct answer = [3]) **[5]**

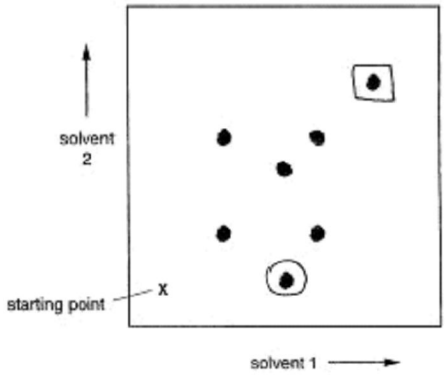
(b) **(i)** berries are aqueous media [1]
PCBs are insoluble/sparingly soluble in water *or* more fat-soluble [1]

(ii) partition coefficient *or* [fat]/[water] is greater than 1 [1]

[3]

(c) **(i)** 4 (four) [1]

(ii)



correct spot circled [1]
correct spot squared [1]
[in each case, more than one spot circled or squared negates the mark] **[3]**

[Total: 11]

Q4.

9 **(a)** spinning proton produces two spin states / magnetic moments (1)
these can align with or against an applied magnetic field (1) [2]

(b) field experienced by protons is influenced by adjacent atoms / protons are in two different chemical environments (1)
peaks are in the area ratio 3 : 1 (methyl to –OH protons)
or are at 0.5 – 6.0δ and 3.3 – 4.0δ (1) [2]

(c) **(i)**

$CH_3CH_2CO_2H$	$CH_3CO_2CH_3$	$HCO_2CH_2CH_3$
propanoic acid	methyl ethanoate	ethyl methanoate

all for (2) two for (1)

(ii) compound is $CH_3CO_2CH_3$ *or* methyl ethanoate (1)
the other two compounds each have 3 different proton environments, but the spectrum shows only 2 peaks. (1)

A is OCH_3, B is CH_3CO (1)

(iii) compound – propanoic acid *or* ethyl methanoate
the –OH proton *or* the H–CO proton (1) [6]

(d) **(i)** distance between atoms / bond lengths / bond angles (1)

(ii) hydrogen atoms (1) [2]
[Total: 12 max 10]

[Total: 10]

Q5.

7 **(a)** The amino acid is uncharged / neutral / a zwitterion *or* charges balance / are equal (NOT "is non-polar")

It is equally attracted by the anode / + and the cathode / – *or* attracted by neither

The pH of the buffer is at the isoelectric point/IEP of the amino acid *any two* ✓✓ (2) [2]

(b) (at pH 10), $H_2NCH_2CO_2^-$ *or* $NH_2CH_2COO^-$ (1) [1]

(c)

amino acid	relative size	charge
A	small(est) (1)	–ve
B	large(st) (3)	–ve
C	middle (2)	+ve

(numbers are OK to show relative sizes)

Mark each row (3) [3]

(d) **(i)** lys – val – ser – ala – gly – ala – gly – asp (2)

(ii) gly – ala – gly (1)

(iii) aspartic acid (*or* lysine) (1) [4]

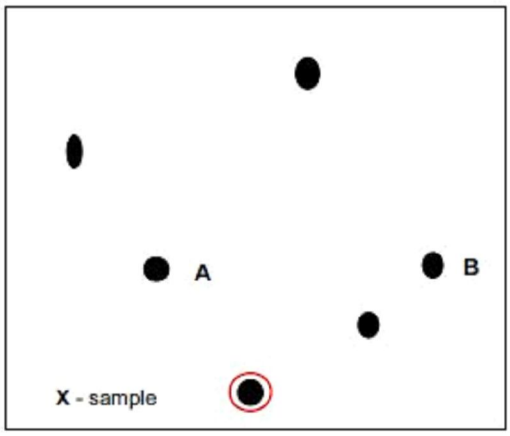
[Total: 10]

Q6.

8 (a) **partition** – separation due to the different solubilities of compounds in two solvents/phases [1]

adsorption – separation due to the different attractions between the compounds and the stationary phase, relative to their solubility in the solvent [1]
Note, if candidates do not refer to different solubilities and different attractions max 1

(b)



Ring: [1]
A + B: [1]

(c) (i) **X** is bromine – M and (M+2) peaks almost same height [1]

(ii) $\frac{M}{M+1} = \frac{100}{1.1} \times \frac{9}{n} = \frac{100}{0.3}$ 1.1 × n

Hence $n = \frac{100 \times 0.3}{1.1 \times 9} = 3.03$ p = 3

(answer + working) [1]

(If the mass peak is at 122 and the compound contains Br and 3 C atoms then Q = (122 – 79 – 36)) thus **Q = 7** ecf from **(ii)** [1]

(The compound is C_3H_7Br)

(iii) *(R is at m/e 43),* hence $\mathbf{C_3H_7^+}$ [1]

(d) Any **two** from H_2, H_2O, CO, C_2H_4, C_2H_2, CH_4 2 × [1]

[Total: 10]

Q7.

7 (a)

Number	Process	Correct sequence (numbers)
A	Place samples on agarose gel	4
B	Use polymerase chain reaction	3
C	Label with radioactive isotope	6
D	Extract DNA	1
E	Use restriction enzyme	2
F	Carry out electrophoresis	5

mark as follows: if **A** is **just** before **F** (i.e. **A** = 4, **F** = 5 *or* **A** = 5, **F** = 6) [1] mark
if **D** = 1 and **E** = 2 [1] mark
if **C** = 6 [1] mark
[3]

(b) (i) P *or* phosphorus (NOT phosphate) [1]

(ii) Phosphate groups are present in DNA *or* it makes the DNA fragments/bands etc. visible *or* locates their position *or* identifies them on a photographic plate etc. [1]
(NOT because it's radioactive *or* makes the bands coloured)
[2]

(c) (i) Yes, all 4 children share one/some band (*or* match/gene/fragment/part/DNA/amino acid) with the mother's (DNA) (NOT the general statement "matches the mother's DNA") [1]

(ii) Child **2**, since he/she shares none of the bands of father's DNA/fingerprint *or* their fingerprint/DNA does not match the father's DNA (the general "match" is OK here) [1]
[2]

(d) (i) Compare DNA fingerprint for **each** fragment (can be read into use of the word 'same' below) [1]
Match the DNA patterns to determine which came from which skin [1]

(ii) A named example of biological origin (N.B. a material, not a whole organism) [1]
e.g. leather (= bull skin), pollen, fish scales, leaves, seeds, feathers, hair, blood, textiles (or a named one like wool or silk or cotton or linen/flax), wood.

(N.B. NOT human or goat skin, also not metal, pottery or stone. If more than one material is given, mark the first one)
[3]

[Total: 10]

Q8.

8 **(a)** Range should be from 10^{-6}–10^{-7} (the left hand arrow) [1]
to 10^{-8}–10^{-9} (the right hand arrow) [1]
[2]

(b) Forms of the **same element** (*or* of **carbon**, since carbon is the context of the question) [1]
with different structures/arrangements of atoms [1]
allow 'different molecular structure', but not structural formula. Any mention of 'compound' negates the mark.
[2]

(c) Nanoparticles are smaller than (animal) cells *or* they can pass through the cell membrane *or* pass into/between cells [1]
Drugs can be bound to/enclosed by the nanoparticle [1]
[2]

(d) (i) Reduction/redox [1]

(ii) M_r of chalcopyrite is 63.5 + 56 + 64 = 183.5
Mass of copper present is 63.5

Hence percentage of copper present = $\frac{63.5 \times 100}{183.5}$ = 34.6% [1]
(if A_r(Cu) = 64 is used, ans = **34.8**%. allow **34–35**%)

(iii) *If the ore contains 2% of chalcopyrite by mass, calculate how much copper is produced from each tonne of ore.*

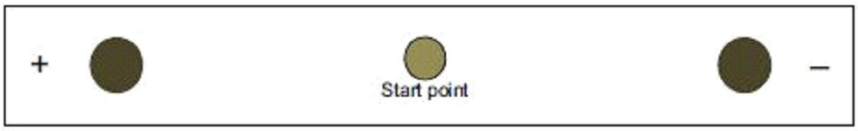
1 tonne = 1000 kg
1 tonne of chalcopyrite would produce 346 kg of copper
1 tonne of 2 % ore would produce 346 × 0.02 or **6.9** kg of copper ecf from **(d)(ii)** [1]
(accept **7.0** or 7 kg)
answer may be given as 7000 g or 7 × 10^{-3} tonnes. If no units are given, assume they are tonnes, and mark accordingly)

(iv) By displacement with a metal (the following specified metals higher than Cu in the ECS may be used: Fe, Zn, Sn, Pb, A*l*, Mg. (NOT Ca, Li, Na. K etc.) *or* with a suitable non-metallic reducing agent, e.g. SO_2 or Sn^{2+}, but not something that wouldn't react, like H_2
or By electrolysis (with carefully controlled voltage) [1]
[4]

[Total: 10]

Q9.

7 (a)



Glutamic acid Glycine Lysine

Glutamic acid between + and start point [1]
Lysine between – and start point [1]
Glycine at, or *very* close to, start point [1]
[3]

(b) (i) Ratio of the concentration of a solute in each of two solvents
or equilibrium constant representing the distribution of a solute between two solvents. [1]

(ii) illustration of some method of getting into our body via the food chain [1]

They dissolve preferentially in fats/oils [1]
[3]

(c) (i) $156 = C_3H_6{}^{35}Cl^{79}Br^+$ [1]
$158 = C_3H_6{}^{37}Cl^{79}Br^+$ [1]
$158 = C_3H_6{}^{35}Cl^{81}Br^+$ [1]
$160 = C_3H_6{}^{37}Cl^{81}Br^+$ [1]

(ii) *m/e* = 15 Species = CH_3^+ [1]
[5 max 4]

[Total: 10]

Q10.

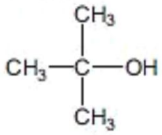
7 **(a) (i) + (ii)** any two from:

- The nature/electronegativity of the atom the proton is attached to *or* is near *or* the electronic/chemical environment of the proton
- The number/spin states of adjacent protons *or* protons attached to adjacent atoms
- The (strength of) the applied/external magnetic field [1] + [1]

[2]

(b) (i) Peak at 1.26δ = (3 ×) CH_3 *or* methyl **and** Peak at 2.0δ = –O–H *or* alcohol [1]

Structure: [1]



(ii)

Isomer	Isomer	Isomer
$CH_3CH_2CH_2CH_2OH$	$(CH_3)_2CHCH_2OH$	$CH_3CH_2CH(CH_3)OH$
5 groups of peaks	4 groups of peaks	5 groups of peaks

structures of any two isomers (Also allow both stereoisomers of butan-2-ol) [1] + [1]
correct assignation of no. of peaks [1] + [1]

[6]

(c) (i) Phosphorus – it has more electrons *or* high electron density (NOT phosphate) [1]

(ii) H atoms don't have enough electron density to show up *or* they only contain one e^- [1]

[2]

[Total: 10]

Q11.

7 **(a)** Any four from:

- extract DNA
- use restriction enzymes (to break DNA into fragments)
- use polymerase chain reaction (to increase concentration of fragments)
- place samples on (agarose) gel
- carry out electrophoresis
- label fragments (transferred to a membrane) with radioactive isotope

[4 × 1]
[4]

(b)

item for testing	suitable for DNA fingerprinting
human hair	✓
piece of a flint tool	✗
piece of Iron Age pot	✗
piece of Roman leather	✓

[3]
[3]

(c) insecticides: gas-liquid *or* thin-layer chromatography [1]

dyes : paper *or* thin-layer chromatography [1]

drugs: gas-liquid
or
thin-layer chromatography [1]
[3]

[Total: 10]

Q12.

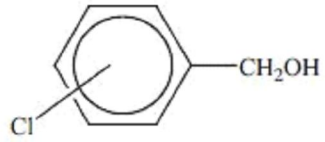
7. **(a) (i)** $\frac{43.3}{3.35} = \frac{100}{1.1 \times n}$

$n = \frac{100 \times 3.35}{43.3 \times 1.1} = 7.03 = 7$ (calculation must be shown) [1]

(ii) The M and M+2 peaks are in the ratio 3 : 1 hence the halogen is chlorine/C*l* [1]

(iii) **L** contains 7 hydrogen atoms *or* there are 3 types/environments of proton/H [1]

(iv) The multiplet with 4 hydrogens *or* peaks at δ 7.3 suggests a benzene ring
The singlet with 2 hydrogens *or* peak at δ 4.7 suggests a $-CH_2-$ group
The singlet with 1 hydrogen *or* peak at δ 2.3 suggests an –OH group
or reaction with Na suggests an OH group
OH must be an alcohol, not a phenol (due to its δ value)
Since **L** also contains 7 carbon atoms and chlorine, this accounts for 126 of the 142 mass, the remaining atom must be oxygen
Thus **L** is



(allow the 2-, 3- or 4- isomer)

[6]
[9 max 7]

(b) (i) we expect propene to have a CH_3 peak *or* a peak at m/e 15
or cyclopropane would have fewer peaks

[1]

(ii) cyclopropane would have 1 peak (ignore splitting)
propene would have 2 (*or* 3, *or* 4) peaks (ignore splitting)
or propene would have peaks in the δ 4.5-6.0 (alkene) region
no splitting of cyclopropane peak
(any two points) [2]
[3]
[Total: 10]

Q13.

9 **(a)** Suitable diagram showing origin of two energy states/or description [1]
Needs to mention applied magnetic field/electron transfer negates
Indication that energy difference is in the radio frequency range [1]
Indication that frequency of absorption *or* gap between the 2 energy states depends on the nature of nearby atoms *or* the chemical environment of the ^{1}H [1]
[3]

(b) They do not damage tissues/X-rays harmful/NMR of lower energy [1]
They are not obscured by bones/skeleton [1]
They can be tuned to examine particular tissues/tumours/*organs*/protons [1]
[max 2]

(c) **(i)** M : M+1 = 100/(1.1n)

$$n = \frac{0.66 \times 200}{14.5 \times 1.1} = \frac{66}{15.95} = 4.14 = 4 \text{ carbon atoms}$$ [1]

Check for 1.1 in divisor, if missing, penalise

(ii) Singlet at δ 2 suggests methyl adjacent to C=O [1]
Quartet at δ 4 suggests a $-CH_2-$ group *(*adjacent to a –methyl group*)* [1]
(allow $-OCH_2-$)
Triplet at δ 1.2 suggests a methyl group *(*adjacent to a $-CH_2-$*)* [1]
G is ethyl ethanoate (or structure)/if methyl propanoate given here cannot score first marking point [1]
[5]

[Total: 10]

Q14.

1 **(a)** **(i)** 162 ($^{81}Br - ^{81}Br^+$) for molecular species [1]
160 ($^{81}Br - ^{79}Br^+$) for atomic species [1]
158 ($^{79}Br - ^{79}Br^+$) *ignore missing charges* for 5 masses [1]
81 ($^{81}Br^+$)
79 ($^{79}Br^+$)

(ii) 158:160:162 =1:2:1 [1]
79:81 =1:1 [1]

(b) **(i)** *either* $BrCH_2CHBr\text{-}CHO$ *or* $CH_2{=}CH\text{-}CH_2OH$ (double bond needed) [1]

(ii) reaction I: Br_2(aq or in CCl_4 etc.), light negates – *solvent not needed* [1]
reaction II: $NaBH_4$ *or* H_2/Ni etc. (but not if **A** is $CH_2{=}CH\text{-}CH_2OH$)
allow $LiAlH_4$ or Na/ethanol [1]
(*reactions can be reversed*)

(c) **(i)** $C_3H_6OBr_2$ = 216, 218 and 220 (any one) [1]

(ii) 31 is CH_2OH^+/CH_3O^+
106 is $C_2H_3{}^{79}Br^+$
108 is $C_2H_3{}^{81}Br^+$
185 is $C_2H_3{}^{79}Br_2{}^+$ *ignore missing charges*
187 is $C_2H_3{}^{79}Br^{81}Br^+$ 6 correct [4]
189 is $C_2H_3{}^{81}Br_2{}^+$ 5 correct [3] etc

if no mass numbers given – [1] only [4]

[Total: 13 max 12]

Q15.

9 (a) (i) cut DNA into sections / fragments / minisatellites [1]

(ii) these undergo electrophoresis OR are placed on agarose gel [1]

(iii) radioactive phosphorus / ^{32}P OR darkens photographic film [1]

(b) (i) NMR can be done in solution / in *vivo* / shows labile protons / shows positions of protons and/or carbon atoms [1]
X-ray crystallography shows the positions of most atoms in structure / allows measurement of bond length [1]

(ii) different types of tissue have protons in different chemical environments / tumour and healthy tissue absorb differently / allow at different frequencies [1]

(c) (i) M : M+1 = 48 : 1.7

$x = \frac{100 \times 1.7}{1.1 \times 48} = 3.2$ hence there are 3 carbon atoms in the compound [1]
NB if calculation shown 1.1 divisor MUST be present

since the compound has an *m/e* of 73 and contains 3 carbon atoms, 1 nitrogen atom and 1 oxygen atom, $y = 73–(36 +14+16) = 7$ [1]

(ii) the NMR spectrum shows a quartet, triplet pattern characteristic of an ethyl group [1]
the other broad peak must be due to N–H protons [1]

thus the structure of the compound is likely to be
$CH_3CH_2CONH_2$ [1]

[Total: 11 max 10]

Q16.

7 (a) (i) Positions of atomic nuclei / atoms (1)

(ii) Insufficient electrons / electron density / electron cloud (around H atom) (1) [2]

(b) X-ray crystallography can show the geometry of the arrangement of atoms / bonding between atoms / shape of atoms (1)

This can help explain how e.g. enzymes work (any reasonable example) (1) [2]

(c) (i) Nuclear spin (1)

(ii) (If M : M+1 gives a ratio 15 : 2)

Then $x = \frac{100 \times 2}{1.1 \times 25} = 7$ (1)

Single peak at 3.7 δ due to $-O-CH_3$ (1)

Single peak at 5.6 δ due to phenol / OH (1)

1,2,1 peak at 6.8 δ due to hydrogens on benzene ring (1)

Pattern suggests 1,4 subsitution (1)

(x = 7,) y = 8, z = 2 (1)

Compound is 4-methoxylphenol (1)

Max 5 [6]

[Total: 10]

Q17.

8 **(a)** Ratio of the concentrations of a solute / distribution of solute [1] in two immiscible liquids [1]
[2]

(b) $K_c = \frac{\text{[pesticide in hexane]}}{\text{[pesticide in water]}}$ hence $8.0 = \frac{\text{[pesticide in hexane]}}{0.0050 - \text{[pesticide in hexane]}}$ [1]

Therefore [pesticide in hexane] $x = 0.040 - 8x$
Hence x = 0.0044(g) [1]
[2]

(c) **(i)** Ratio would be 3 : 1 [1]

(ii) Each chlorine at could be ^{35}Cl or ^{37}Cl
Only way of getting M+4 is for both chlorines to be ^{37}Cl (1 in 9 chance) [1]
Ratio of peaks M M+2 M+4
9 6 1 [1]
[3]

(d) **(i)** Accept dioxins and furans (without specifying) [1]

(ii) PCBs (but don't penalise non-specified dioxins and furans) [1]

(iii) Allow : pollution control / environmental legislation / removal of dioxins and furans / mill closed down (owtte) [1]

(iv) Five [1]
[4]

[Total: 11]

Q18.

8 **(a)** Protons (1)
in NMR, energy is absorbed due to the two spin states (1)
Electrons (1)
in X-ray crystallography, X-rays are diffracted (by regions of high electron density) (1) **[4]**

(b) **(i)** 1 – no mark
The spectrum of alcohol / **Y** contains different peaks
Alcohol / **Y** contains different chemical environments
Spectrum 2 contains only one peak (1)

(ii) Spectrum 2 only shows 1 peak so **Z** must be a ketone (1)

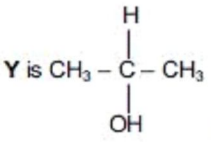
Hence **Y** must be a 2° alcohol (1)

Number of carbon atoms present $= \frac{0.6 \times 100}{17.6 \times 1.1} = 3$ (1)

Thus **Z** must be CH_3COCH_3 (1)

Hence **Y** must be propan-2-ol, $CH_3CH(OH)CH_3$ (1)

(iii)



Y is (1)

(iv) All of the protons in **Z** are in the same chemical environment (1) **[8] max [7]**

[Total: 11]

Q19.

10 (a) (i) Partition – substance is distributed between the stationary and mobile phase *or* has different solubility in each phase (1)
Adsorption – substances form bonds of varying strength with *or* are attracted to *or* are held on to stationary phase. (1)

(ii)

Technique	Separation method
Paper chromatography	Partition
Thin-layer chromatography	Adsorption
Gas/liquid chromatography	Partition

3 correct → (2)
2 correct → (1)

(iii) %**X** = 44% (±2) %; %**Y** = 56% (±2%) (1) **[5]**

(b) (i) They are largely composed of (carbon and) hydrogen which are active in the NMR (owtte) *or* protons/H^+/H exist in <u>different chemical environments</u> (with characteristic absorptions) (1)

(ii) 2 correct displayed formulae (1)

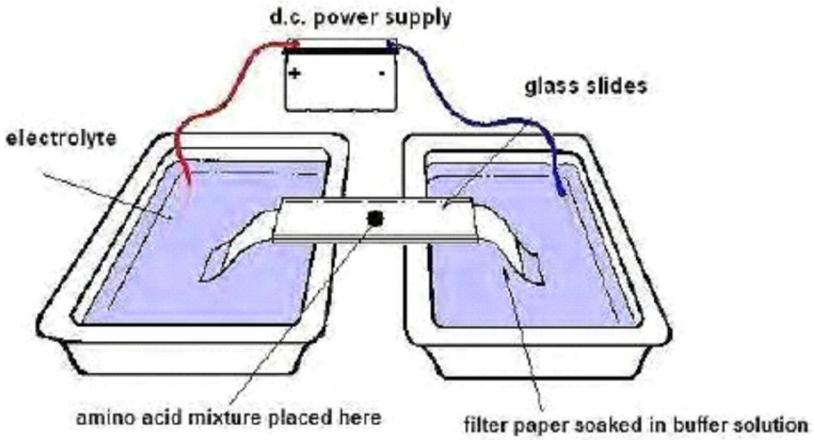
In propanone all the protons are in a similar chemical environment (and hence there will be one proton peak.) (1)

In propanal there are (three) <u>different chemical environments</u> and hence there will be (three) <u>proton peaks</u> *or* three different chemical environments *or* three proton peaks (1)
[4]

[Total: 9]

Q20.

7 (a) Sketch and label the apparatus used to carry out electrophoresis e.g



Marks: power supply / electrolyte + filter paper / buffer / acid mixture central — 4 × [1]
[4]

(b) (i) pH of the buffer — [1]
Charge on the amino acid species — [1]

(ii) Size of the amino acid species / M_r — [1]
Voltage applied — [1]
Magnitude of the charge (on the amino acid species) — [1]
Temperature — [1]
(max 3)
[max 3]

(c) (i) They have insufficient electron density / only one electron — [1]
(ii) Sulfur — [1]
because it has the greatest atomic number / number of electrons — [1]
[3]

[Total: 10]

Q21.

7 (a)

structural information	analytical technique
three-dimensional arrangement of atoms and bonds in a molecule	X-ray crystallography/diffraction
chemical environment of protons in a molecule	NMR (spectroscopy) **only**
identity of amino acids present in a polypeptide	Electrophoresis / chromatography / mass spectrometry

[1] + [1] + [1]
[3]

(b) (i) **paper chromatography;**
The components **partition** between the solvent/moving phase and the water/liquid stationary phase *or* separation relies on different solubilities (of components) in the moving solvent and the stationary water phase. [1]

(ii) **thin-layer chromatography.**
Separation depends on the differential **adsorption** of the components onto the solid particles/phase *or* Al_2O_3 *or* SiO_2. [1]
[2]

(c) (i) No. of carbon atoms present = $\frac{0.2 \times 100}{5.9 \times 1.1}$ = 3.08 hence 3 carbons [1]

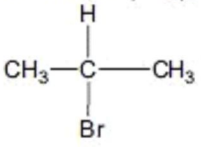
(ii) Bromine [1]

(iii) **One** bromine is present as there is only an M+2 peak / no M+4 peak *or* the M and M+2 peaks are of similar height [1]

(iv) *NMR spectrum shows a single hydrogen split by many adjacent protons and 6 protons in an identical chemical environment. This suggests...*
two $-CH_3$ groups and a lone proton attached to the central carbon atom [1]

Empirical formula of **N** is C_3H_7Br [1]

Hence **N** is $(CH_3)_2CHBr$ *or*



[1]
[6]

[Total: 11]

Q22.

7 (a) (i) Electrophoresis [1]

(ii) Using a restriction enzyme. [1]

(iii) The phosphate group. [1]

[3]

(b) (i) **X labelled** correctly on diagram. [1]

(ii) Suspect 2 **AND** matches crime scene 1 or matches at least one crime scene. [1]

[2]

(c) **P** is $CH_3CO_2CH_2CH_3$ [1]

any <u>four</u> of:

- 3 different (proton) environments
- (M and M+1 data shows no of carbons present is) $(100 \times 0.22)/(1.1 \times 5.1) =$ **4 carbons**
- the NMR spectrum shows 8 hydrogens leaving 32 mass unit or 2 oxygen ***or*** $M_r = 88$ **and** (molecular formula is) $C_4H_8O_2$
- 4 peaks/quartet (at 4.1) shows an adjacent $3H/CH_3$
- 3 peaks/triplet (at 1.3) shows an adjacent $2H/CH_2$
- (peak at) 2.0/singlet shows CH_3CO (group)
- (peak at) 4.1/quartet **and** 1.3/triplet shows presence of ethyl/CH_3CH_2 (group)

4 × [1]

[5]

[Total: 10]

Q23.

7 (a) (i) No. of carbon atoms present in **J** is $\frac{100 \times 1.3}{1.1 \times 23.5}$ = 5 carbons (must show working) [1]

(NMR spectrum shows) **10 H** (atoms present) (no reasoning need be shown) [1]

(ii) Oxygen **or** O_2 **or** O [1]

(iii) **J** is $(CH_3CH_2)_2C=O$ [1]

any one from:
quartet/4 peaks (at δ 2.5) shows an adjacent CH_3 **or** 3 adjacent H
triplet/3 peaks (at δ 1.1) shows an adjacent CH_2 **or** 2 adjacent H
two (chemical/hydrogen) environments
pair of peaks in ratio 6 :4 are (two) ethyl groups **or** the triplet + quartet shows an ethyl group
δ 2.5 implies there's a CH_2 next to C=O [1]

[Total: 5]

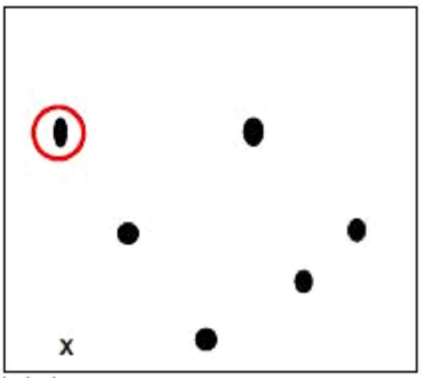
(b) (i)

technique	***physical method***
paper chromatography	**partition**
thin-layer chromatography	**adsorption**
gas-liquid chromatography	**partition**

[2]

(ii) 4 [1]

(iii)



correct spot circled [1]

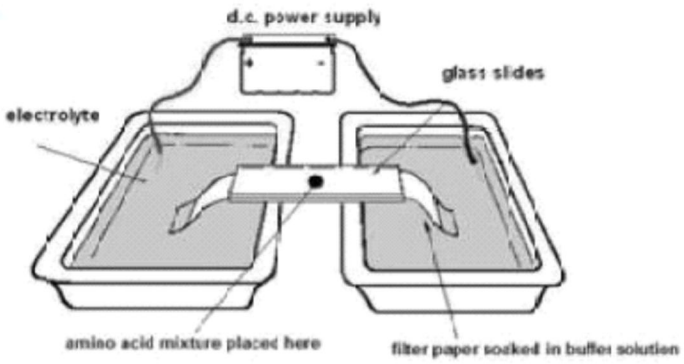
(iv) 3 [1]

[Total: 5]

[TOTAL: 10]

Q24.

7 (a)



power supply (idea of complete circuit)
electrolyte/buffer solution
gel/filter paper/absorbent paper
(amino acid) sample/mixture [centre of plate] 4 × [1]

[4]

(b) *any two from:*
size/M_r (of the amino acid species)
charge (on the amino acid species)
temperature 2 × [1]

[2]

(c) Ratio of the concentration of a solute in each of two (immiscible) solvents
or equilibrium constant representing the distribution of a solute between two solvents
or $PC = [X]_a/[X]_b$ (at a constant temperature) [1]

[1]

(d) (i) K_{pc} = [Z in ether]/[Z in H_2O] – allow reverse ratio
40 = (x/0.05)/((4–x)/0.5) [1]

= **3.2 g** ecf [1]

(ii) First extraction
40 = (x/0.025)/((4–x)/0.5)
x = **2.67 g** ecf [1]

(iii) Second extraction: 1.33g remain in solution
Second extraction
40 = (y/0.025)/((1.33–y)/0.5)
y = **0.887 g**

mass extracted = 2.67 + 0.89 = **3.56/3.6 g** ecf [1]

[4]

[Total: 11]

Q25.

8 **(a)** NMR **and** radiowaves (*or* VHF/UHF *or* 40 – 800 MHz) [1]
[1]

(b) NMR: protons have (nuclear) spin
or (spinning) proton produces magnetic moment/field *or* two spin states
or protons can align with or against an applied magnetic field [1]

there is insufficient electron density/cloud around H atoms for X-ray crystallography [1]
[2]

(c) Sulfur, because it has the highest electron density [1]
[1]

(d) **(i)** $\frac{4.5}{1.5} = \frac{100}{1.1} \times n$

$n = \frac{100 \times 0.15}{4.5 \times 1.1} = 3.03 = \mathbf{3}$ (calculation must be shown) [1]

(ii) the –OH peak (broad singlet) at δ 4.6 [1]

(iii) 3 (three) [1]

(iv) **Q** has peak at 11.7δ. [1]
which is due to $-CO_2H$ [1]
(This can only be formed by oxidising a *primary* alcohol.)

or **P** has 4 peaks in its NMR spectrum, not 3 [1]
in a secondary alcohol with 3 carbons, two (methyl) groups will be in the same chemical environment (or wtte) [1]

or analysis of the splitting pattern in **P**: the peaks at δ 0.9 and 3.6 are triplets, [1]
so each must be adjacent to a $-CH_2-$ group. (hence $-CH_2-CH_2-CH_3$) [1]

(v) $CH_3CH_2CO_2H$ (**structure** needed, not name) [1]
[6]

[Total: 10]