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MARKSCHEME

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CHEMISTRY

Higher Level

Paper 3

16 pages

OPTION C – HUMAN BIOCHEMISTRY

C1. (a) Chemical messenger / OWTTE ***[1]***

(b) (i) Testes ***[1]***

*(Note: Do not award **[1]** for ovaries, since in humans the production of testosterone by the ovaries is extremely low in comparison with the testes.)*

(ii) Use (*e.g.* treatment of wasting illness / to regain muscle tissue, treatment of eczema) ***[1]***;
Abuse (*e.g.* increase muscle mass to enhance performance / increase strength) ***[1]***;

Second use or second abuse ***[1]***.

[3 max]

(c) Two groups circled correctly ***[1]***;
Two correct corresponding names***[1]***.

Accept any two from the following:
- Alkanol / alcohol / hydroxyl;
- Alkene;
- Alkanone / ketone / carbonyl.

(Do not accept CH_3 / methyl / alkyl group or 'hydroxide')

[2 max]

(d) *Allow any one from:*
- Cholesterol has an OH group instead of the $C=O$ group in testosterone;
- Cholesterol has an alkyl/hydrocarbon side-chain instead of the OH group in testosterone;
- There is no carbonyl group present in cholesterol;
- The position of the $C=C$ bond is different in cholesterol compared to testosterone.

(Or any other correct answer, relating to structural differences.)

[1 max]

C2. (a) Glycerol / propane-1,2,3-triol *(accept correct structure)*. ***[1]***

(b) Fatty acid(s) / salt of acid / soap / carboxylic acid / alkanoic acid / carboxylate. ***[1]***

(c) Heat with base / alkali / KOH / NaOH (*both needed*). ***[1]***

(d) Heat produced = (mass × specific heat capacity × ΔT) *(can be scored by implication)* ***[1]***;
= (500 × 4.18 × 67.5) ***[1]***;
= 141.075 / 141075 J***[1]***.

Calorific value of bar = $\frac{50.0}{10.0} \times 141.075$;
= 705.4 (kJ) / 705 (kJ) *(accept correct value in J)* ***[1]***.

[4 max]

C3. (a) Hydrogen bond ***[1]***;
Two H-bonds shown between T and A ***[1]***;
Three H-bonds shown between C and G ***[1]***;
Deoxyribose and phosphate (*both needed*) ***[1]***;

- Phosphate on one nucleotide bonds to (OH of) deoxyribose on the next nucleotide ***[1]***;
- Condensation reaction / by covalent bonding ***[1]***.

[6 max]

(b) *Award* ***[1]*** *each for any four of the following points:*

- Separate DNA from other material ***[1]***;
- Cut DNA up (using restriction enzymes) ***[1]***;
- Separate by electrophoresis ***[1]***;
- Method of detection (*e.g.* UV, radioactive probe, X-ray) ***[1]***.

[4 max]

OPTION D – ENVIRONMENTAL CHEMISTRY

D1. (a) Water / CFCs / dinitrogen oxide (N_2O or nitrous oxide / O_3 / HCFCs / HFCs / SF_6). ***[1]***
(Accept correct formula instead of a name).

(b) (i) *Any two sources, **[1]** each*
e.g. Respiration (by animals) / decay of plants or animals / oxidation of soil humus / forest fires caused by lightning / volcanoes / combustion of fossil fuels and wood / burning trash (rubbish).
[2 max]

(ii) *Any two sources, **[1]** each*
e.g. Bacterial fermentation / bogs or marshes / digestive tracts of ruminants. Rotting waste in land-fill sites.
[2 max]

(c)
- Lower energy / longer wavelength / infrared radiation from the Earth ***[1]***;
- Greenhouse gases absorb / retain / trap this energy ***[1]***;
- Some reference to how the gases absorb this energy *e.g.* vibration ***[1]***.

[3 max]

D2. (a) (i)
- Solid objects / example of this (*e.g.* rock) ***[1]***;
- Grids / screens / sand bed (*do not accept filter*) ***[1]***.

[2 max]

(ii)
- Metal ions / phosphate ***[1]***;
- Alkali / sulfide / Ca^{2+} / calcium ions (accept a named calcium compound) ***[1]***.

[2 max]

(b) (i) *Any two of the following **[1]** each*
- Similar anti-bacterial action achieved with smaller [O_3] ;
- O_3 more effective than Cl_2 (against waterborne viruses);
- O_3 imparts no chemical taste to water;
- O_3 does not form harmful chlorine containing organic compounds.

[2 max]

(ii) O_3 must be produced on site (because of high reactivity) / O_3 has a shorter retention time. ***[1]***

D3.
- NO_x produced in the exhaust gases ***[1]***;
- Sunlight converts the oxides of nitrogen into oxygen radicals (oxygen atoms) / $NO_x + \text{sunlight} \rightarrow O\bullet$ ***[1]***;
- The oxygen atoms react with hydrocarbons in the exhaust gases / $O\bullet + HC \rightarrow$ ***[1]***;
- This reaction produces alkanals ***[1]***;
- Which form PAN / peroxyacylnitrates***[1]***.

Any two of the following, ***[1]*** *each*
Cause irritation of the eyes / respiratory problems / damage to plants.

Numerous answers are possible here, all ***[1]*** *each:*
- Use catalytic converters which convert oxides of nitrogen into harmless nitrogen;
- Less car usage;
- Change to othr fuels *e.g.* electric.

[10 max]

OPTION E – CHEMICAL INDUSTRIES

E1. (a) **Heats** the furnace / OWTTE ***[1]***.

Any valid reaction involving coke, *e.g.* reduces iron oxide / is converted to carbon monoxide ***[1]***.

[2 max]

(b) (i) Oxygen is blown through (the molten iron). (*Do not accept 'air' here*) ***[1]***;
It oxidises / converts the carbon into carbon dioxide gas (which escapes) ***[1]***.

[2 max]

(ii) Calcium oxide / lime is added (to the molten iron). (*Allow limestone*) ***[1]***;
Calcium oxide reacts (with the silica) to form calcium silicate / slag ***[1]***.

[2 max]

E2. (a) Any appropriate equation (*must have alkane and alkene as products*) ***[1]***;
One use of an alkane (*e.g.* fuel) ***[1]***;
One use of an alkene (*e.g.* polymer or name of polymer) ***[1]***.

[3 max]

(b) (i) Silica / aluminium oxide / zeolites. ***[1]***

(ii) **Heat** / high temperature / temperature above $300\,^{\circ}\mathrm{C}$; ***[1]***

(c) Catalytic cracking produces a mixture of **alkanes and alkenes** ***[1]***;
Hydrocracking produces **alkanes** only ***[1]***.

[2 max]

E3. Any reasonable answer *e.g.* the products of refining are **flammable** and hence there is a risk of fire. ***[1]***

Any reasonable answer *e.g.* the gas produced in the furnace must not be released as it contains poisonous carbon monoxide. ***[1]***

E4. $1\ \mathrm{mol(g)} \rightarrow 2\ \mathrm{mol(g)}$ so $\Delta S^{\ominus}$ increases / entropy change positive ***[1]***;
At higher T, $\Delta G^{\ominus}$ becomes more negative as $T\Delta S^{\ominus}$ becomes greater ***[1]***;

[2 max]

500 K $\mathrm{C} \rightarrow \mathrm{CO_2}$ more negative $\Delta G^{\ominus}$
2000 K $\mathrm{C} \rightarrow \mathrm{CO}$ more negative $\Delta G^{\ominus}$ ***[1]***;
More negative $\Delta G^{\ominus}$ favoured ***[1]***.

[2 max]

E5. Cathode half-reaction: $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ (*state symbols not needed*) ***[1]***;
Anode half-reaction: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$ (*state symbols not needed*) ***[1]***;

[1] *each for any* ***three*** *of the following:*
Porous membrane;
Aqueous electrolyte / brine;
Positive electrode / anode: titanium graphite;
Negative electrode / cathode: steel.

Any reasonable advantage **and** disadvantage ***[1]***.

[6 max]

OPTION F – FUELS AND ENERGY

F1. (a) (i) 1 % ***[1]***

(ii) Inappropriate wavelengths ***[1]***;
Reflected / heats the surface / not all areas covered by plants ***[1]***.
[2 max]

(b) (i) Photosynthesis. ***[1]***

(ii) $6H_2O + 6CO_2 \rightarrow C_6H_{12}O_6 + 6O_2$ ***[1]***
(No marks if not balanced.)

(c) (i) *Any two of the following,* ***[1]*** *each*
- Combustion;
- Production of biogas;
- Production of ethanol / fermentation.

[2 max]

(ii) *(Allow* ***[1]*** *for any reasonable advantage and* ***[1]*** *for any reasonable disadvantage.)* ***[2]***

(d) (i)
- Heat ***[1]***;
- Pressure ***[1]***;
- Absence of oxygen ***[1]***.

[3 max]

(ii) *Any three of the following,* ***[1]*** *each*
- Specific example of pollution (*e.g.* oil spills);
- Cost of production / transport;
- Non-renewable;
- More valuable as a feedstock.

[3 max]

F2. (a) Metals conduct electricity well, insulators do not, semiconductors are intermediate;
*(Must have all 3 points for **[2]**, 2 correct points for **[1]**)*

[2 max]

(b) Converts solar energy to electricity ***[1]***;
Si or Ge ***[1]***;
Doped with group 5/As or other example ***[1]***;
Doped with group 3/B or other example ***[1]***;
Light stimulates electron flow ***[1]***.

*If mention n-type and p-type but do not explain, award only **[1]** of the **[2]** doping marks.*

Any reasonable advantage **and** disadvantage ***[1]***.

[6 max]

(c) **voltage** depends on **materials** used ***[1]***;
Power depends on the **quality** of materials ***[1]***.

[2 max]

OPTION G – MODERN ANALYTICAL CHEMISTRY

G1. (a) Mass spectrometry. ***[1]***

(b) Chlorine exists as **two isotopes**. ***[1]***

(c) II: $^{37}Cl^{+}$ ***[1]***
IV: $(^{35}Cl - ^{37}Cl)^{+}$ ***[1]***

[2 max]

(d) The ratio of the isotopes is 1 : 3 /25 % ^{37}Cl and 75 % ^{35}Cl ***[1]***;
This is the ratios of the peak heights/intensities ***[1]***.
(Graph must be referred to for second mark.)

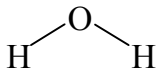
[2 max]

(e) (i) By bombarding with electrons. ***[1]***

(ii) The molecular mass of the compound. ***[1]***

G2. (a) ***d* to *d*** transitions / transitions within the ***d*** sub-level. ***[1]***

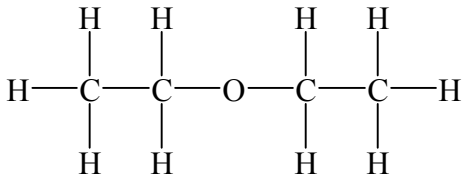
(b) X-ray crystallography. ***[1]***

G3. (a)  ***[1]***;

$O = C = O$ *(accept linear shape without double bond)* ***[1]***;
Bond length changes / stretching ***[1]***;
Bond angle changes / bending ***[1]***;
Dipole moment changes ***[1]***.

[5 max]

(b) (i) $CH_3CH_2OCH_2CH_3$ / ethoxyethane / diethylether ***[1]***;

 ***[1]***;

- No broad brand at 3230 – 2550 cm^{-1} / no OH present ***[1]***;
- Therefore not alkanol or acid ***[1]***;
- No absorption 1680 – 1750 cm^{-1} / C=O present ***[1]***;
- Therefore not acid or ester ***[1]***.

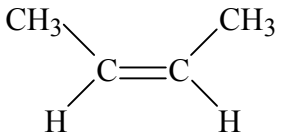
[6 max]

(ii) $CH_3CH_2CO_2H$ has absorptions at 2500–3300 and 1680–1750 cm^{-1} ***[2]***;
$CH_3CH_2CH_2OH$ has an absorption at 3230–3550 cm^{-1} ***[1]***;
$CH_3CH_2CO_2CH_2CH_3$ has an absorption at 1680–1750 cm^{-1} ***[1]***.

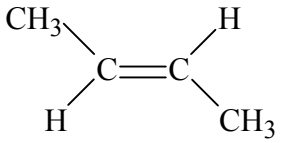
[4 max]

OPTION H – FURTHER ORGANIC CHEMISTRY

H1. (a) (i)



cis-but-2-ene

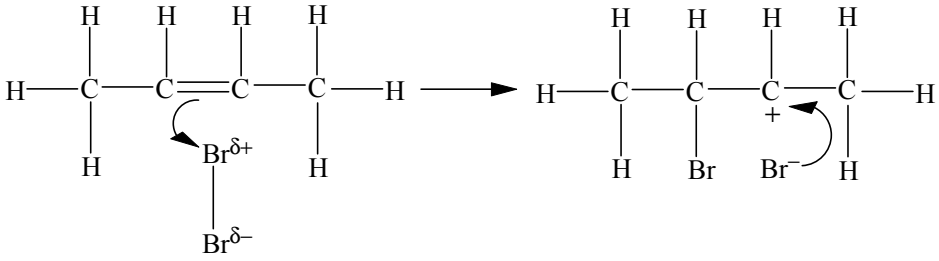


trans-but-2-ene

Each correct structure ***[1]*** each;
Both correct names ***[1]***.

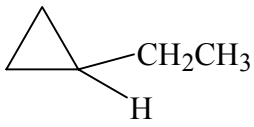
[3 max]

(ii)

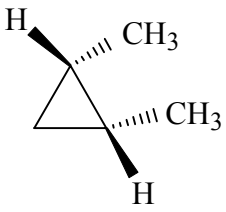


[1] ***[1]*** ***[2 max]***

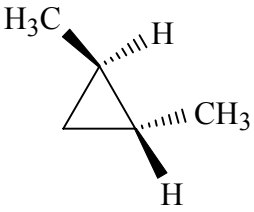
(b) (i) **A**:



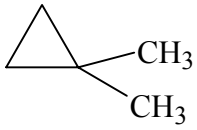
B:



C:



D:



*(Award **[1]** for each correct structure. Use ECF where possible if straight chain C_5 molecules given)*

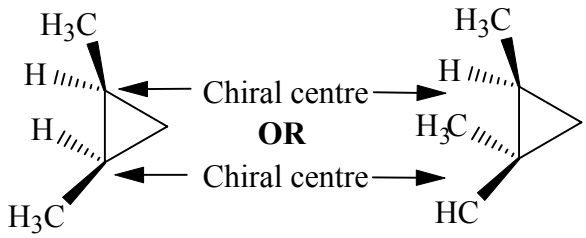
[4 max]

(ii) Structural: **A** and **D** / **A** and **B** / **A** and **C** / **B** and **D** / **C** and **D** ***[1]***.

Geometrical: **B** and **C** ***[1]***.

[2 max]

(iii) (iii)



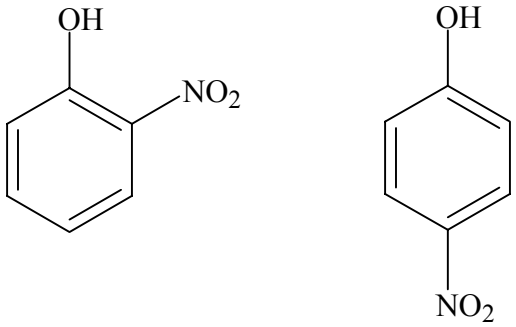
Correct structure ***[1]***.
Chiral centre marked ***[1]***. ***[2 max]***

(c) No rotation (in either but-2-ene or cycloalkanes) ***[1]***;
Without breaking the π component (in but-2-ene) and the ring (in cycloalkanes) ***[1]***;
(Both points are needed for the second mark here.)

[2 max]

(d) More strain / bond angles $< 109.5^{\circ}$. ***[1]***

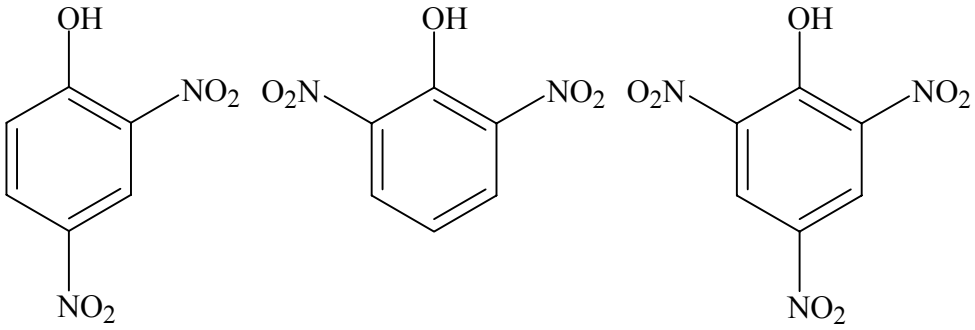
H2. (a)



X **Y**

Structures for nitrophenols, ***[1]*** each.

Z



Structure for dinitrophenol/trinitrophenol *(Only one of structures above is needed.)* ***[1]***
In phenol, lone pair of electrons on oxygen overlaps with delocalised ring ***[1]***.
Activates the ring / attracts electrophiles or NO_2^+ more strongly / increases electron density ***[1]***.

[5 max]

(b) Nitro group is electron-withdrawing ***[1]***;
Bond polarity of O—H increased / more H^+ ions released ***[1]***;
Z has the most electron-withdrawing groups ***[1]***;
Correct reference to the stability of the anion ***[1]***. ***[4 max]***