WAKISHA JOINT MOCK EXAMINATIONS 2026

CHEMISTRY - DETAILED MARKING GUIDE & MODEL ANSWERS

Items 1-6 | Worked calculations | Mechanisms | Synthesis | Examiner notes

IMPORTANT NOTE FOR TEACHERS
This document reconstructs the visible questions from the photographs supplied in the chat and provides a UNEB-style marking presentation. The original mark allocations are not visible in the photographs, so 20 marks per item are used as a practical reconstructed allocation. This is not an official Wakissha Joint Mock or UNEB marking scheme. Award credit for scientifically correct equivalent methods, equations and explanations.

Paper structure reconstructed from the photographs

Section	Instruction visible in paper	Items covered in this guide
SECTION A	Respond to both items.	Item 1 and Item 2
SECTION B - Part I	Respond to one item from this part.	Item 3 or Item 4
SECTION B - Part II	Respond to one item from this part.	Item 5 or Item 6

Suggested marking conventions

- M = method/working shown; A = accurate result or conclusion; E = valid explanation; R = correct reaction/equation; C = consequence/linked point.
- Do not award the same mark twice for one statement. A correct final answer without essential working should lose the working mark where working is explicitly requested.
- Follow-through: where an early numerical mistake is carried consistently into a later step, award consequential marks when the later method is correct.
- Accept equivalent chemical equations, catalysts and valid industrial alternatives when chemically correct and appropriate to the question.

ITEM 1: Green chemistry: hydrogen peroxide fuel cell versus octane ICE

20 marks reconstructed

A. Model solution

(a) Energy generated

The half-cell with the higher reduction potential is reduced at the cathode. The lower-potential half-cell is reversed and operates as the oxidation reaction at the anode.

```
Cathode: H2O2 + 2H+ + 2e- -> 2H2O        E° = +1.77 V

Anode:   H2O2 -> O2 + 2H+ + 2e-        E°ox = -0.68 V

Overall: 2H2O2 -> 2H2O + O2

E°cell = E°cathode - E°anode(reduction) = 1.77 - 0.68 = +1.09 V

ΔG° = -nFE° = -(2)(96500)(1.09) J mol-1 = -2.1037 x 10^5 J mol-1

ΔG° = -210.4 kJ per 2 mol H2O2; equivalently -105.2 kJ mol-1 H2O2
```

For the internal-combustion engine, use Hess' law with the given enthalpies of formation:

```
2C8H18 + 25O2 -> 16CO2 + 18H2O

ΔH°rxn = ΣΔHf(products) - ΣΔHf(reactants)

= [16(-394) + 18(-286)] - [2(-250) + 25(0)]

= [-6304 - 5148] - [-500]

= -10952 kJ for the equation as written

Per 1 mol C8H18: -10952/2 = -5476 kJ mol-1 octane
```

Interpretation
The fuel-cell voltage gives the maximum electrical work as ΔG, not the total reaction enthalpy. Thus the fuel-cell value and the ICE enthalpy are different thermodynamic quantities. The fuel cell is thermodynamically feasible because E°cell > 0 and ΔG° < 0. The observed lack of bubbles at room temperature indicates a kinetic barrier rather than thermodynamic impossibility.

(b) Overcoming the high activation energy

- Use a suitable catalyst/electrocatalyst, e.g. a catalyst on the electrodes, to provide a reaction pathway of lower activation energy.
- Increase temperature moderately where safe; higher temperature increases the fraction of particles with energy at or above Ea and therefore increases rate.
- Increase effective reactant concentration/partial pressure and improve contact at the electrode; this can increase collision/electron-transfer frequency.
- Increase electrode surface area and improve mixing/mass transfer so the reactants reach active sites efficiently.
- Remove products or continuously supply reactants in a controlled cell if this improves the operating rate.

• A catalyst changes the rate (Ea) but does not change ΔG°, E°cell or the equilibrium position.

Common error
Do not say that a catalyst makes an otherwise non-spontaneous reaction spontaneous. It lowers Ea and speeds a thermodynamically feasible reaction.

Marking guide - Item 1 (20 marks)

No.	Expected response / evidence	Marks
1	Correctly identifies H2O2 reduction as cathode process using the +1.77 V half-cell.	**2**
2	Correctly reverses the O2/H2O2 half-reaction for oxidation.	**1**
3	Correct overall reaction: 2H2O2 -> 2H2O + O2.	**2**
4	E°cell = 1.77 - 0.68 = +1.09 V.	**2**
5	Uses ΔG° = -nFE° with n = 2 and F = 96500 C mol-1.	**2**
6	ΔG° = -210.4 kJ per 2 mol H2O2 (or -105.2 kJ mol-1 H2O2).	**1**
7	Correct Hess-law expression for octane combustion.	**2**
8	Correct substitution and arithmetic: -10952 kJ for 2 mol octane.	**1**
9	Normalised value: -5476 kJ mol-1 octane (energy released = 5476 kJ mol-1).	**1**
10	Explains kinetic difficulty/high Ea and gives two or more valid measures: catalyst, temperature, concentration/contact, electrode area/mass transfer.	**3**
11	States correctly that catalyst lowers Ea but does not change ΔG°/E°cell.	**1**

ITEM 2: Freezing-point depression: choosing a road-de-icing salt

20 marks reconstructed

A. Model solution

For glucose, i = 1 because it is a non-electrolyte. Use ΔTf = Kf m, where m is molality in mol kg-1 of water.

Mass of water = 360 g = 0.360 kg; RFM glucose = 180 g mol-1.

Glucose mass (g)	Moles of glucose	Molality (mol kg-1)	ΔTf (°C)	Kf (°C kg mol-1)
1.80	1.80/180 = 0.0100	0.0100/0.360 = 0.02778	0.052	0.052/0.02778 = 1.872
3.60	0.0200	0.05556	0.103	1.854
9.00	0.0500	0.13889	0.258	1.858
18.00	0.1000	0.27778	0.517	1.861

```
Average Kf = (1.872 + 1.854 + 1.858 + 1.861)/4 = 1.861 ≈ 1.86 °C kg mol-1
```

Mass of salt needed to lower 1.0 kg water from 0 ℃ to -8.0 ℃

```
Required ΔTf = 8.0 °C

ΔTf = iKfm
```

For NaCl, assume ideal dissociation into 2 ions, i ≈ 2:

```
m = 8.0/(2 x 1.861) = 2.149 mol kg-1

For 1.0 kg water: n = 2.149 mol

mass NaCl = 2.149 x 58.4 = 125.5 g
```

For CaCl2, assume ideal dissociation into 3 ions, i ≈ 3:

```
m = 8.0/(3 x 1.861) = 1.433 mol kg-1

For 1.0 kg water: n = 1.433 mol

mass CaCl2 = 1.433 x 110.8 = 158.8 g
```

Decision
NaCl is the better choice under the stated criterion because about 125.5 g NaCl is required versus about 158.8 g CaCl2 for the same idealised 8.0 °C freezing-point depression. In real roads, ion pairing, moisture, temperature and application conditions mean the ideal calculation is an approximation.

(b) Environmental concerns and responses

- Chloride released in meltwater can increase salinity of streams, wetlands and soils; elevated salinity can stress freshwater organisms and vegetation.
- Repeated chloride loading can contaminate surface water and groundwater and can contribute to soil structure/vegetation problems.
- Both NaCl and CaCl2 can accelerate corrosion of vehicles, bridges and metal infrastructure; CaCl2 also releases more chloride per mole and, in this calculation, a larger applied mass is required.
- Apply only the minimum effective amount, calibrate spreaders and avoid application immediately before heavy rain.

- Use pre-wetting/brine where appropriate, physical snow removal, traction materials and lower-chloride alternatives where practical.

- Protect waterways with drainage controls, vegetated buffers and monitoring of chloride concentrations; store salt under cover.

Marking guide - Item 2 (20 marks)

No.	Expected response / evidence	Marks
1	Recognises ΔTf = Kf m for glucose and converts 360 g water to 0.360 kg.	**2**
2	Correct glucose calculation for 1.80 g: n = 0.0100 mol, m = 0.02778 mol kg-1, Kf = 1.872.	**2**
3	Correct Kf calculations for the other three data points.	**3**
4	Average Kf ≈ 1.86 °C kg mol-1.	**1**
5	NaCl: i = 2; m = 8/(2Kf) ≈ 2.149 mol kg-1.	**2**
6	NaCl mass ≈ 125.5 g for 1.0 kg water.	**1**
7	CaCl2: i = 3; m = 8/(3Kf) ≈ 1.433 mol kg-1.	**2**
8	CaCl2 mass ≈ 158.8 g; selects NaCl as requiring the smaller mass.	**1**
9	Two or more valid environmental concerns: salinity, aquatic/vegetation stress, soil/groundwater contamination, corrosion.	**3**
10	Two or more feasible mitigation measures.	**2**
11	Notes limitations of ideal i values/real-road conditions.	**1**

ITEM 3: Halogen acids in three industrial chambers

20 marks reconstructed

A. Identification from the evidence

Chamber A = HF

- HF has the highest boiling point in the table, +19.9 °C, so it is easiest to liquefy near room temperature at relatively low pressure.
- HF attacks silica in ordinary glass, so glass-lined vessels are unsuitable. Teflon/plastic equipment is used because fluorinated polymer materials are resistant to HF under suitable conditions.

```
SiO2 + 4HF -> SiF4 + 2H2O
```

- HF is a weak acid in water because the H-F bond is strongest (568 kJ mol-1), so ionisation is relatively difficult; hence slower reaction with Mg than HCl/HI under the stated observation.

Chamber A process link
For frost glass/etching, HF reacts with silica and therefore removes the glass surface. The key evidence is the glass attack plus the relatively high boiling point.

Chamber B = HCl

- Hydrogen chloride is a common, comparatively cheap and stable industrial acid used for pickling steel to remove rust/scale before galvanising.
- Its boiling point is very low (-85.1 °C), so storage as a liquefied gas needs much stronger cooling/pressure control than HF. This matches the inspection observation.

```
Mg + 2HCl -> MgCl2 + H2
```

- HCl is a strong acid in water because the H-Cl bond is much weaker than H-F, so it ionises readily and reacts vigorously with Mg.

Chamber C = HI

- HI has the weakest bond in the table (299 kJ mol-1), making H-I bond cleavage easiest. This is consistent with strong reducing behaviour.
- A red-hot wire can promote decomposition/oxidation processes that liberate iodine; iodine vapour is characteristically purple/violet.

```
2HI -> H2 + I2
```

```
Mg + 2HI -> MgI2 + H2
```

- HI is therefore suitable where a strong reducing agent and catalyst/precursor is required, as stated for pharmaceutical synthesis.

Trend
Bond strength decreases HF > HCl > HI, while ease of H-X bond cleavage and reducing character increase down the group. Boiling point is not the same trend because boiling point depends on intermolecular forces and molecular properties, not bond energy alone.

(b) Health and environmental impacts

- HF: highly corrosive and particularly hazardous because fluoride can penetrate tissue and cause deep burns and systemic toxicity; exposure requires specialised emergency control.
- HCl and HI: corrosive acids/vapours that can cause severe eye/skin burns and respiratory irritation or injury.
- Iodine vapour is an inhalation irritant; acid mist and halide emissions can affect workers and nearby environments.
- Discharges can acidify water/soil and alter aquatic chemistry; fluoride/chloride/iodide-containing wastes require controlled treatment rather than direct release.
- Use closed transfer systems, corrosion-resistant equipment, local exhaust/scrubbers, compatible PPE, spill containment, emergency showers/eyewash and controlled neutralisation of waste.

Marking guide - Item 3 (20 marks)

No.	Expected response / evidence	Marks
1	Correctly identifies Chamber A as HF and links to boiling point +19.9 °C.	**2**
2	Explains HF attacks glass/silica; correct equation or equivalent description.	**2**
3	Explains HF weak-acid/strong H-F bond behaviour and slower Mg reaction.	**2**
4	Correctly identifies Chamber B as HCl and links to industrial steel pickling, cost/stability and very low bp.	**3**
5	Correct Mg + 2HCl -> MgCl2 + H2 equation and strong-acid explanation.	**1**
6	Correctly identifies Chamber C as HI and links to lowest H-I bond energy.	**2**
7	Explains reducing action and violet iodine vapour; valid equation accepted.	**2**
8	At least two worker-health hazards.	**2**
9	At least two environmental impacts and at least one control measure.	**2**
10	Clear comparison of boiling point, bond energy and acid/reducing behaviour.	**2**

ITEM 4: Group II hydroxides: trends, reactivity, health and environmental selection

20 marks reconstructed

A. Interpreting the data

1. Decomposition temperature

- The given decomposition temperatures increase down the group: Be(OH)2 138 °C < Mg(OH)2 330 °C < Ca(OH)2 450 °C < Sr(OH)2 540 °C < Ba(OH)2 780 °C.

```
M(OH)2 --heat--> MO + H2O
```

- Down the group, the Group II cation becomes larger and has lower charge density/polarising power. The hydroxide ion is therefore less strongly polarised, so the hydroxide is thermally more stable and needs a higher temperature to dehydrate/decompose.

2. Solubility

- The data show Be(OH)2 is insoluble; Mg(OH)2 is only sparingly soluble; Ca(OH)2 and Sr(OH)2 are more soluble; Ba(OH)2 remains appreciably soluble in the data.

- The table has an apparent Sr/Ba irregularity (Sr 3.4 x 10^-2 versus Ba 1.52 x 10^-2 mol/100 g water). Do not invent a smooth trend that contradicts the supplied data; describe the general increase from Mg to the heavier hydroxides and acknowledge the observed anomaly.

- Solubility reflects the balance between lattice enthalpy and hydration enthalpy. As the cation becomes larger, lattice attraction generally weakens, making dissolution easier; the exact trend also depends on hydration effects.

3. Interaction with sulfuric acid

```
M(OH)2 + H2SO4 -> MSO4 + 2H2O
```

- Important sulfate-solubility differences affect the reaction. BaSO4 is very insoluble and forms a heavy precipitate; SrSO4 is sparingly soluble; CaSO4 is sparingly soluble; MgSO4 is much more soluble.

```
Ba(OH)2 + H2SO4 -> BaSO4(s) + 2H2O
```

- The insoluble sulfate removes Ba2+ from solution and can affect reaction completeness/precipitation control.

4. Interaction with sodium hydroxide

- Most Group II hydroxides are already bases and do not have a significant acid-base reaction with NaOH under ordinary conditions.

- Be(OH)2 is amphoteric and can dissolve in excess NaOH to form a soluble beryllate complex:

```
Be(OH)2 + 2NaOH -> Na2[Be(OH)4]
```

B. Choice of hydroxide(s) for practical use

- Mg(OH)2 is a suitable antacid because it is sparingly soluble, so it does not generate an excessively concentrated alkaline solution. It neutralises stomach acid: Mg(OH)2 + 2HCl -> MgCl2 + 2H2O.

- Mg(OH)2 is also useful as a fire retardant because its endothermic decomposition absorbs heat and releases water vapour, helping cool and dilute combustible gases.

- Ca(OH)2 is useful where a stronger/more soluble alkaline material is needed, including alkaline hydrolysis/saponification-related processes and neutralisation of acidic materials.
- Sr(OH)2 and especially Ba(OH)2 provide stronger soluble alkaline solutions but are less attractive for routine consumer/industrial use because of cost, handling and toxicity concerns; Ba compounds require particular caution.
- Be(OH)2 should not be selected for ordinary consumer applications because beryllium compounds are highly hazardous; its amphoteric chemistry is a special laboratory/industrial property rather than a safety advantage.

Marking guide - Item 4 (20 marks)

No.	Expected response / evidence	Marks
1	Correct decomposition equation M(OH)2 -> MO + H2O.	**2**
2	Correctly states increase of decomposition temperature down the group using data.	**2**
3	Valid explanation using cation size/charge density/polarising power and hydroxide stability.	**3**
4	Interprets the solubility data without contradicting the supplied Sr/Ba values.	**2**
5	Explains lattice-vs-hydration balance in solubility.	**2**
6	Correct sulfuric-acid equation and precipitate/solubility discussion, especially BaSO4.	**3**
7	Correctly states most Group II hydroxides do not react appreciably with NaOH; identifies Be(OH)2 amphoterism.	**2**
8	Gives one or more correct practical choices with reasons (MgOH2, CaOH2 etc.).	**2**
9	Identifies relevant toxicity/health/environmental considerations, especially Be/Ba hazards.	**2**

ITEM 5: 1,2-Dibromoethane (EDB), solvents and environmental mitigation

20 marks reconstructed

A. Reading the scenario correctly

- EDB is 1,2-dibromoethane. The question states that it is used as the active ingredient in a fumigant and that it is dissolved in propan-2-ol as a co-solvent.
- The environmental recommendation is to transform EDB chemically into a less problematic product and to replace/modify the solvent. The industrial intern also proposes aqueous NaOH substitution and an esterification of propan-2-ol.

1. Reaction of EDB with aqueous sodium hydroxide

```
BrCH2CH2Br + 2NaOH(aq) -> HOCH2CH2OH + 2NaBr
```

- This is nucleophilic substitution: OH- replaces each Br atom, giving ethane-1,2-diol (ethylene glycol).
- Ethane-1,2-diol is used as an engine coolant/antifreeze because it depresses the freezing point and has a relatively high boiling point.

Important chemistry check on the stated mitigation
The photograph states that EDB should be transformed into 2-methylphenol and that propan-2-ol should become 2-methylpropan-2-ol. Neither is a simple one-step conversion from the stated starting material: EDB has only two carbons whereas 2-methylphenol has seven, so additional carbon atoms and multiple synthetic steps would be required. Also propan-2-ol (C3) cannot become 2-methylpropan-2-ol (C4) without a carbon-addition step. A strong marking response should flag this and then show a chemically feasible route or the intern's simpler, directly supported reactions.

2. A chemically feasible route from propan-2-ol to 2-methylpropan-2-ol

```
CH3CHOHCH3 + [O] -> CH3COCH3 + H2O

CH3COCH3 + CH3MgBr -> (CH3)3COMgBr

(CH3)3COMgBr + H3O+ -> (CH3)3COH + Mg2+ salts
```

- Thus propan-2-ol is first oxidised to propanone; a methyl Grignard reagent adds a carbon atom; acidic work-up gives 2-methylpropan-2-ol. This is a multi-step laboratory synthesis, not direct rearrangement.

3. Esterification suggested by the intern

```
CH3CHOHCH3 + CH3COOH <=> CH3COOCH(CH3)2 + H2O
```

- The product is propan-2-yl ethanoate (isopropyl ethanoate), an ester with a pleasant fragrance. Use a strong acid catalyst and heat under controlled conditions; distil/separate the ester after reaction.

4. How to handle the 2-methylphenol claim

- Do not award a direct EDB -> 2-methylphenol equation because the carbon skeleton does not balance. A valid answer must introduce a phenyl/methyl carbon framework through separate reactions.
- For environmental mitigation, a simpler and directly supported substitution/dehalogenation approach is to convert EDB to less halogenated/oxygenated products under controlled treatment, such as ethane-1,2-diol via aqueous OH- as given by the intern.
- Industrial-scale transformation should be assessed by yield, waste, toxicity of intermediates, energy use and whether the replacement product is genuinely safer. A product should not be called greener solely because it is chemically different.

(b) Health and environmental assessment

- EDB and its vapour present significant worker and environmental hazards; its volatility makes inhalation control important, and releases can contaminate air/soil/water.
- Fumigation chemicals can expose workers, nearby communities and non-target organisms. Closed handling, leak detection and controlled application are essential.
- Ethane-1,2-diol is useful but is also hazardous if ingested; a greener replacement must be managed safely and kept away from children/animals.
- Propan-2-ol and ester products are flammable; ignition sources must be controlled and solvent vapours contained.
- Use closed reactors, local exhaust, compatible gloves/eye protection, spill containment, labelled containers and segregated chemical waste. Do not discharge bromide-containing waste to waterways.

Examiner focus
A high-quality response separates (i) what the paper explicitly states, (ii) what the intern proposes, and (iii) what is chemically feasible. Credit the intern's aqueous-NaOH reaction fully; critically evaluate the stated EDB -> 2-methylphenol and propan-2-ol -> tert-butanol conversions rather than forcing an impossible equation.

Marking guide - Item 5 (20 marks)

No.	Expected response / evidence	Marks
1	Identifies EDB as 1,2-dibromoethane and recognises the purpose of chemical mitigation.	**1**
2	Correct balanced EDB + 2NaOH(aq) -> ethane-1,2-diol + 2NaBr equation.	**3**
3	Explains nucleophilic substitution at both C-Br centres.	**2**
4	Links ethane-1,2-diol to engine coolant/antifreeze and environmental substitution rationale.	**2**
5	Correctly flags that EDB cannot directly become 2-methylphenol because the carbon skeleton changes from C2 to C7; needs additional carbon/multiple steps.	**2**
6	Correctly explains that propan-2-ol -> 2-methylpropan-2-ol needs carbon addition and is not direct.	**2**
7	Provides a chemically valid multi-step route for the tert-alcohol transformation, or gives another valid carbon-addition route.	**2**
8	Correct esterification: propan-2-ol + ethanoic acid -> propan-2-yl ethanoate + water, with acid catalyst/heat.	**2**
9	At least two health/environmental hazards plus appropriate controls.	**3**
10	Shows critical green-chemistry judgement: safer products, lower waste, containment, energy/yield considerations.	**1**

ITEM 6: Carbonyl compounds: propanone and ethanal

20 marks reconstructed

A. (a) Boiling point and solvent properties

- Ethanal boils at 20.2 °C, while propanone boils at 56 °C. Both contain a polar carbonyl group and have dipole-dipole and London dispersion forces, but propanone has a larger molar mass/electron cloud and therefore stronger London dispersion forces overall.
- Neither has an O-H group, so neither forms strong self hydrogen-bond networks like alcohols do. The carbonyl dipole contributes significantly to intermolecular attraction.
- Propanone is generally the better laboratory solvent in the stated comparison because it is a useful polar aprotic solvent and is relatively resistant to oxidation under ordinary conditions; ethanal is readily oxidised to ethanoic acid and is more reactive.

(b) Synthesis pathways

1. Ethanal -> phenylethanone (acetophenone)

```
2CH3CHO + O2 -> 2CH3COOH

CH3COOH + SOCl2 -> CH3COCl + SO2 + HCl

C6H6 + CH3COCl --AlCl3--> C6H5COCH3 + HCl
```

- The final reaction is Friedel-Crafts acylation of benzene. CH3CO+ (acylium ion) is the electrophile and AlCl3 is the Lewis-acid catalyst.

2. Ethanol -> propanone

```
CH3CH2OH + 2[O] -> CH3COOH + H2O

2CH3COOH + Ca(OH)2 -> Ca(CH3COO)2 + 2H2O

Ca(CH3COO)2 --strong heat--> CH3COCH3 + CaCO3
```

- The calcium ethanoate is dry-distilled/strongly heated. The ketonic decarboxylation gives propanone.

(c) Reaction mechanisms and synthesis of 2-hydroxypropanoic acid

1. Propanone oxime

```
CH3COCH3 + NH2OH -> (CH3)2C=NOH + H2O
```

- Step 1 - nucleophilic addition: the nitrogen of NH2OH attacks the electrophilic carbonyl carbon of propanone, forming a tetrahedral intermediate.
- Step 2 - proton transfers occur, followed by elimination of water and formation of the C=N-OH group. The product is propanone oxime.

Mechanism sketch in words
Carbonyl carbon (partial positive) <- NH2OH nitrogen lone pair; tetrahedral carbinolamine intermediate -> dehydration -> C=N-OH.

- Propanone oxime can act as an antiskinning additive by reacting with/limiting oxidation processes associated with surface-film formation in paint systems, as intended in the question context.

2. Ethanal + acidified KCN/HCN: cyanohydrin formation

```
CH3CHO + HCN -> CH3CH(OH)CN
```

- Mechanism: CN- attacks the electrophilic carbonyl carbon of ethanal, pushing the C=O pi electrons onto oxygen. The resulting alkoxide is protonated to give the cyanohydrin, 2-hydroxypropanenitrile (lactonitrile).
- The nitrile group is then hydrolysed under acidic aqueous conditions on heating:

```
CH3CH(OH)CN + 2H2O + H+ -> CH3CH(OH)COOH + NH4+
```

- The product is 2-hydroxypropanoic acid (lactic acid). In practice, the cyanide step is highly hazardous and requires professional controls.

(d) Safety, health and environmental assessment

- Ethanal, propanone and many esters are volatile/flammable; keep away from flames/sparks, use a fume hood and minimise vapour release.
- Ethanal is readily oxidised and can irritate eyes and respiratory tissues; store and handle in closed containers.
- KCN/HCN is exceptionally hazardous. Acidifying cyanide can release HCN gas; therefore cyanide work must never be performed casually in an open school laboratory. Use trained supervision, a fume hood, dedicated cyanide controls and emergency procedures.
- Grignard reagents, thionyl chloride and AlCl3 (where used) are moisture-reactive/corrosive and require dry apparatus, controlled addition and appropriate PPE.
- Organic solvent vapours are VOCs; prevent release, recover/recycle solvents where practical and dispose of residues through approved waste streams.
- For a school club, teacher demonstrations or safer substitute reactions are preferable to student handling of cyanide, HF, concentrated HI/HCl or highly reactive reagents.

Core examiner judgement
The safest and strongest answer connects physical properties to molecular structure, writes balanced synthesis equations, gives the key nucleophilic-addition mechanism for HCN and oxime formation, and identifies cyanide as a critical hazard.

Marking guide - Item 6 (20 marks)

No.	Expected response / evidence	Marks
1	Explains boiling-point difference using molar mass/electron cloud and London dispersion together with carbonyl dipoles.	**2**
2	Identifies propanone as the better solvent and gives valid reasons (polarity + relative oxidation stability/usefulness).	**2**
3	Ethanal oxidation to ethanoic acid and conversion to ethanoyl chloride or equivalent acyl source.	**2**
4	Correct Friedel-Crafts acylation equation to phenylethanone with AlCl3.	**2**
5	Valid synthesis of propanone from ethanol through ethanoic acid -> calcium ethanoate -> ketonic decarboxylation.	**2**
6	Correct propanone + hydroxylamine oxime equation.	**2**
7	Clear nucleophilic addition/elimination mechanism for oxime formation.	**1**
8	Correct ethanal + HCN/cyanide to cyanohydrin equation and mechanism description.	**2**
9	Correct acidic hydrolysis to 2-hydroxypropanoic acid.	**1**
10	Identifies major safety/environment hazards and controls, especially HCN/KCN, flammability and VOCs.	**4**

FINAL EXAMINER CHECKLIST

1. Numerical answers to verify
Item 1: E°cell = +1.09 V; ΔG° = -210.4 kJ for 2 mol H2O2; octane combustion = -10952 kJ for 2 mol C8H18, or -5476 kJ mol-1 octane. Item 2: Kf ≈ 1.86 °C kg mol-1; NaCl ≈ 125.5 g and CaCl2 ≈ 158.8 g for 1.0 kg water to reach -8.0 °C (ideal i).

2. High-value equations
Fuel cell: 2H2O2 -> 2H2O + O2. Octane: 2C8H18 + 25O2 -> 16CO2 + 18H2O. De-icing: ΔTf = iKfm. EDB: BrCH2CH2Br + 2NaOH(aq) -> HOCH2CH2OH + 2NaBr. Oxime: CH3COCH3 + NH2OH -> (CH3)2C=NOH + H2O. Lactic acid route: CH3CHO + HCN -> CH3CH(OH)CN -> CH3CH(OH)COOH.

3. Critical conceptual checks
Do not confuse thermodynamic feasibility (E°cell/ΔG°) with reaction rate (Ea). Do not confuse boiling point with bond energy. Do not force impossible carbon-skeleton changes in Item 5. For Item 6, the cyanide route is chemically valid but carries a severe safety hazard.

Teacher use note

This guide is designed as a detailed model-answer/marking aid. For classroom marking, the teacher may replace the reconstructed 20-mark allocation with the official mark allocation if the original typed examination paper or official mark scheme becomes available. Equivalent scientifically correct answers should be credited where they satisfy the question.