CBC ITEMS CHEMISTRY A LEVEL SCORING GUIDE

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***ITEM 1: KATWE SOLDERING – EUTECTIC ALLOY**

*(a) Define Eutectic Mixture *

A eutectic mixture is a mixture of two or more components which melts and solidifies at a single temperature that is lower than the melting points of any of the individual pure components.

***Significance of Eutectic Point *:** It is the lowest temperature at which the liquid phase can exist. The mixture melts sharply like a pure substance, ensuring uniform flow and strong joints in soldering.

***(b) Phase Diagram Sketch ***

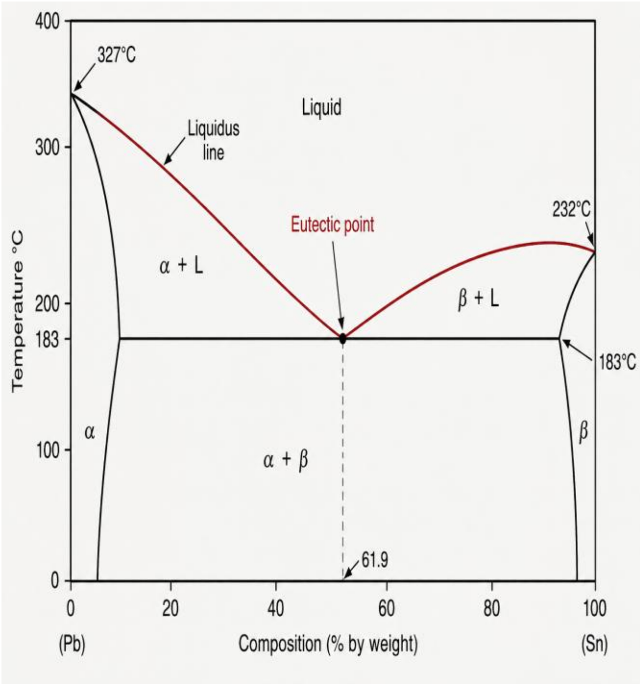
- X-axis: % Pb, 0% to 100%. Y-axis: Temperature °C.

- Mark pure Sn mpt = 232°C at 0% Pb. Mark pure Pb mpt = 327°C at 100% Pb.

- Liquidus lines: slope from 232°C and 327°C down to meet at Eutectic Point: 62% Sn, 38% Pb, 183°C.

- Solidus line: Horizontal at 183°C across whole composition range.

- Label regions: Liquid, Liquid + Solid Sn, Liquid + Solid Pb, Solid mixture.



***(c) 90% Pb cooled 350°C→200°C ***

At 350°C: fully liquid. At ~300°C: crosses liquidus, solid Pb begins to crystallize out. At 200°C: mixture of solid Pb crystals + liquid alloy. Only fully solidifies at 183°C.

*Vs Eutectic 38% Pb *: Eutectic remains fully liquid until 183°C, then solidifies sharply to fine solid mixture. No pasty range. Gives better joints for electronics.

***(d) Why replacement must be eutectic ***

1. Low melting point protects heat-sensitive components.

2. Sharp melting ensures good wetting and flow. Pure metal mp too high. Random mixture has wide pasty range → dry/weak joints.

*ITEM 2: OWEN FALLS DAM – SACRIFICIAL PROTECTION

*(a) Define SEP *: Emf of a half-cell connected to standard hydrogen electrode under standard conditions: 1M, 298K, 1 atm.

*Salt bridge essential *: Completes circuit, maintains charge balance by ion migration, prevents liquid junction potential.

*(b) Diagram Fe^{2+}/Fe cell *: Beaker with 1M $FeSO_4$(aq), Fe rod. Salt bridge to SHE: Pt, 1M H^+, H_2 at 1 atm. Voltmeter between. Label anode/cathode, electron flow.

*(c) Cell notation *: Mg(s)|Mg^{2+}(aq,)||Fe^{2+}(aq)|Fe(s)

*(d)(i) E°cell Mg-Fe *: E°cathode – E°anode = -0.44 – (-2.37) = *+1.93 V*

*(ii) Cu + Fe^{2+} *: E°cell = -0.44 – 0.34 = *-0.78 V* < 0. Not spontaneous. Cu cannot reduce Fe^{2+}.

*(iii) Which metal *: *Use Mg*. E°(Mg^{2+}/Mg) = -2.37V is more negative than E°(Fe^{2+}/Fe) = -0.44V. Mg oxidizes preferentially: Mg → Mg^{2+} + $2e^-$. Electrons flow to Fe structure, Fe^{2+} + $2e^-$ → Fe. Fe stays reduced = protected. This is sacrificial protection. Cu E° = +0.34V > -0.44V, so Fe would corrode to protect Cu. Useless.

ITEM 3: APAC HEALTH CENTRE – ELECTROLYSIS H_2SO_4

*(a) Half-equations *

Cathode: $2H^+$(aq) + $2e^-$ → H_2(g)

Anode: $4OH^-$(aq) → O_2(g) + $2H_2O$(l) + $4e^-$ _OH^- from water discharged preferentially_

*(b) Volume O_2 *

Q = It = 2.5 × 4 × 3600 = *36,000 C*

Moles e^- = 36000/96500 = *0.373 mol*

$4e^-$ → $1O_2$, so moles O_2 = 0.373/4 = *0.0933 mol*

Volume at s.t.p = 0.0933 × 22.4 = *2.09 dm^3*

*(c) Using Cu electrodes *

Cu is not inert. Anode: Cu(s) → Cu^{2+} + $2e^-$ because E°(Cu^{2+}/Cu) = +0.34V < E°(O_2/H_2O) = +1.23V.

Impact: 1. Copper anode dissolves, gets used up. 2. Electrolyte contaminated with blue Cu^{2+} ions. 3. No O_2 produced. Not suitable for modeling battery or pure O_2.

ITEM 4: BUSIA CHLORINE PLANT – HALOGENS

*(a) Trend atomic radius *: Increases down Group 17. More electron shells, increased shielding, outer e^- further from nucleus. Electronegativity decreases because nuclear attraction for bonding e^- decreases.

*(b) Ionic equation *: Cl_2(g) + $2I^-$(aq) → $2Cl^-$(aq) + I_2(aq)

*(c) Redox *: I^- oxidized to I_2, oxidation state -1→0. Cl_2 reduced to Cl^-, 0→-1.

*(d) Oxidizing power *: $I_2 < Br_2 < Cl_2$. Down group, radius↑, shielding↑, electron affinity↓. Cl has highest electron affinity, least shielding → attracts e^- most readily → strongest oxidizer.

*(e) NaI vs NaCl with conc H_2SO_4 *:

Cl^- is weak reducing agent. Cannot reduce H_2SO_4. Only HCl formed: $NaCl + H_2SO_4 \rightarrow NaHSO_4 + HCl$.

I^- is strong reducing agent. Reduces H_2SO_4: $8HI + H_2SO_4 \rightarrow 4I_2 + H_2S + 4H_2O$. $H_2SO_4 \rightarrow H_2S$ rotten egg. $I^- \rightarrow I_2$ purple vapor. Reaction complex due to redox.

***ITEM 5: MBARARA BATTERY RECYCLING – GROUP IV**

*(a) Trend +4 vs +2 *: Down C→Pb, +4 becomes less stable, +2 more stable. Due to *inert pair effect*: $6s^2$ e^- in Pb poorly shielded by 4f, 5d. Hard to remove. Bond energy M–X decreases down group, +4 not favored.

*(b) Amphoteric *: PbO reacts with acids and bases.

*(c) With HNO_3 *: $PbO + 2HNO_3 \rightarrow Pb(NO_3)_2 + H_2O$

*(d) With NaOH *: $PbO + 2NaOH + H_2O \rightarrow Na_2[Pb(OH)_4]$

*(e) CCl_4 vs $SiCl_4$ *: C has no vacant d-orbitals, cannot expand octet. Not attacked by H_2O. Si has vacant 3d orbitals. H_2O attacks: $SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$. White fumes = HCl.

*(f) PbO_2 + HCl *: $PbO_2 + 4HCl \rightarrow PbCl_2 + Cl_2 + 2H_2O$

$Pb^{4+} + 2e^- \rightarrow Pb^{2+}$. +4 unstable due to inert pair effect. Pb^{2+} has stable $6s^2$. So PbO_2 oxidizes HCl to Cl_2, itself reduced to +2.

***ITEM 6: KCCA PLASTIC WASTE – POLYMERS**

*(a) Polymerization *: *A*: Addition polymerization. *B*: Condensation polymerization.

Difference: Addition = no small molecule lost. Condensation = H_2O eliminated.

*(b) Repeating unit A *: $–CH_2–CH_2–$

*(c) Nylon-6,6 *: $HOOC–(CH_2)_4–COOH + H_2N–(CH_2)_6–NH_2 \rightarrow –[CO–(CH_2)_4–CO–NH–(CH_2)_6–NH]– + 2H_2O$. _***Circle –CO–NH– amide link***_

*(d) **Why B stronger *:** Polyamide has polar –CO–NH– groups. Forms strong interchain H-bonds. Chains pack closely. High energy to break → high mpt, strong.

Polyethene only weak van der Waals forces. Chains slide easily. Low mpt, weak.

*(e) **Why PE non-biodegradable** *: C–C and C–H bonds only. Non-polar. No functional groups for enzymes. C–C bond 347 kJ/mol too strong. No hydrolysis.

*(f**) Modify to biodegrade** *: Introduce ester/amide links in backbone. e.g., copolymerize with glycolic acid. Ester bonds hydrolyzed by water/bacteria. Or blend with starch.

*****ITEM 7: NAKAWA LAB – COMPOUNDS

*(a) Mass C, H,O *:

C: 6.16 × 12/44 = *1.68 g*. H: 0.90 × 2/18 = *0.10 g*. Ca = *0.40 g*.

O: 2.82 – 1.68 – 0.10 – 0.40 = *0.64 g*

***(b) Empirical formula *:**

Moles: C=0.14, H=0.10, O=0.04, Ca=0.01. Ratio 1:14:10:4. *$CaC_{14}H_{10}O_4$*

*(c) Molecular formula *: Mr empirical = 282 = Mr given. *$Ca(C_7H_5O_2)_2$*. Compound S = *Calcium benzoate*.

***(d)(i) Pyrolysis *: $Ca(C_6H_5COO)_2 \rightarrow CaCO_3 + C_6H_5COC_6H_5$**

*(ii) Compound K *: ***Benzophenone***. IUPAC**: Diphenylmethanone**. C_6H_5–CO–C_6H_5

*(iii) Distinguish acid from phenol *: Add $NaHCO_3$.

Benzoic acid → CO_2 effervescence.

Phenol → no reaction.

*(e) Use of K *: UV absorber in plastics, perfumes, sunscreens.