

## Mark Scheme - PI1.1 Redox and Standard Electrode Potentials

- 1 (a)  $1 \text{ dm}^3$  at  $20^\circ\text{C}$  contains  $52.9 \text{ g}$  and at  $0^\circ\text{C}$  it contains  $17.5 \text{ g}$  (1)  
 $\therefore$  amount crystallised =  $52.9 - 17.5 = 35.4 \text{ g}$  (1) [2]
- (b) (i)  $2 \text{ mol}$  of  $\text{K}_2\text{S}_2\text{O}_8$  give  $1 \text{ mol}$  of  $\text{O}_2$   
 $2 \text{ mol}$  of  $\text{K}_2\text{S}_2\text{O}_8$  give  $29.0 \text{ dm}^3$  of  $\text{O}_2$  (1)  
 $\therefore 0.1 \text{ mol}$  of  $\text{K}_2\text{S}_2\text{O}_8$  gives  $29.0/20 = 1.45 \text{ dm}^3$  of oxygen (1) [2]
- (ii) Measure the volume of oxygen produced at specified time intervals /  
 Measure the pH of the solution at specified time intervals [1]
- (c) (i) An (inert) electrode that is used to carry the charge / current / electron flow [1]
- (ii) A comment on the relative values (e.g. the persulfate system is the more positive of the two systems) (1)  
 The more positive 'reagent' / persulfate ions acts as the oxidising agent, accepting electrons via the external circuit (1)  
 - must have the first mark to get second [2]
- (d) (i) The experiments show that both the concentrations of iodide and persulfate have doubled (1) therefore the initial rate should increase four times  
 $4 \times 8.64 \times 10^{-6} = 3.46 \times 10^{-5}$  (1) [2]
- (ii) Rate =  $k [\text{S}_2\text{O}_8^{2-}] [\text{I}^-]$  (1)  
 $\therefore k = \frac{8.64 \times 10^{-6}}{0.0400 \times 0.0100}$   
 $= 0.0216$  (1)  $\text{dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$  (1) [3]
- (iii) In the rate equation one  $\text{S}_2\text{O}_8^{2-}$  ion reacts with one  $\text{I}^-$  ion.  
 The rate-determining step therefore has to have 1 mole of each reacting, as (only) seen in step 1 [1]

Total [14]

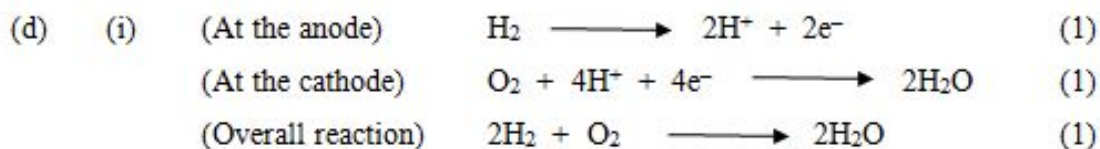
- 2 Both  $O_2$  and  $O_3$  have oxidation states of zero (1) No change in oxidation state (1) [2]
- 3 (a) diagram with labels to show
- $H_2/H^+$  shown in electrode (1)
  - platinum (in both electrodes) (1)
  - $Fe^{2+}(aq)$  and  $Fe^{3+}(aq)$  (1)
  - high resistance voltmeter (1)
  - salt bridge (1)
  - gas at 1atm pressure, solutions of concentration  $1 \text{ mol dm}^{-3}$ , temperature 298K (1)
- [any 5] [5]
- (b) (i) successive ionisation energies increase gradually/ the energies of the d orbitals are similar [1]
- (ii)  $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} / 3d^{10} 4s^2$  [1]
- (iii) after 4s electrons lost 3d is full/ stable/ d electrons ionisation energy very high [1]
- (c) (i) violet solution contains  $V^{2+}$  (1)
- SEP  $Zn^{2+}/Zn$  is more negative than  $VO_3^-/VO^{2+}$  and  $VO^{2+}/V^{3+}$  and therefore releases electrons/  $VO_3^-/VO^{2+}$  and  $VO^{2+}/V^{3+}$  are more positive than  $Zn^{2+}/Zn$  and are stronger oxidising agents (1)
- $V^{2+}$  cannot be reduced (to V) since SEP is more negative than  $Zn^{2+}/Zn$  (1) [3]
- (ii) 1.1V (ignore sign) [1]
- (iii)  $Zn(s) \rightarrow Zn^{2+}(aq) + 2e^- / Zn(s) \rightleftharpoons Zn^{2+}(aq) + 2e^-$  with some indication of direction [1]
- (iv) if  $Zn^{2+}(aq)$  concentration increased equilibrium moves to LHS (1)
- so electrode potential becomes less negative (1) [2]

- (d) (i)  $2.74 \times 10^{-3}$  (mol) [1]  
(ii)  $1.37 \times 10^{-3}$  (mol) [1]  
(iii)  $M_r \text{KIO}_3 = 214.1$   
moles  $\text{KIO}_3 = 0.978 / 214.1 = 4.57 \times 10^{-3}$  in  $250 \text{ cm}^3$   
 $4.57 \times 10^{-4}$  in  $25 \text{ cm}^3$  [1]  
(iv)  $1.37 \times 10^{-3} / 4.57 \times 10^{-4} = 3$  (1)  
equation 1 is correct since 3 moles of iodine formed (mark awarded for reason) (1) [2]

Total [20]

- 4 (a) (i) Oxidising agent [1]  
(ii) A = lead(II) chloride /  $\text{PbCl}_2$  (1)  
B = chlorine /  $\text{Cl}_2$  (1) [2]  
(iii)  $[\text{Pb}(\text{OH})_6]^{4-}$  /  $[\text{Pb}(\text{OH})_4]^{2-}$  /  $\text{Na}_4[\text{Pb}(\text{OH})_6]$  etc. [1]  
(iv) Yellow [1]  
(v)  $\text{PbO} + 2\text{HNO}_3 \longrightarrow \text{Pb}(\text{NO}_3)_2 + \text{H}_2\text{O}$  [1]
- (b) (i) Each C atom covalently bonded to three other C atoms forming layers (1)  
Layers held together by weak intermolecular forces (1)  
BN is isoelectronic with C so it forms similar structures (1)  
Graphite conducts electricity since electrons are delocalised but in BN, each N has a full unbonded p-orbital and each B has an empty unbonded p-orbital so it does not conduct electricity (1) [4]  
(Accept electrons are not delocalised in BN so it does not conduct electricity)  
*QWC The information is organised clearly and coherently, using specialist vocabulary where appropriate* [1]
- (ii) Wear-resistant coatings/catalyst support/for mounting high power electronic components / drills in industry / cutting instruments [1]
- (c) (i)  $\Delta G = \Delta H - T \Delta S$  ( $\Delta G = 0$  for reaction to be spontaneous) (1)  
 $T = \frac{1.92}{0.0067}$  (1)  
 $T = 286.6 \text{ K}$  (1) [3]  
(ii) Changes in temperature (above or below 286.6 K) caused the tin to change form making it unstable (and causing it to disintegrate) [1]





[3]

- (ii) Hydrogen is difficult to store / takes up large volume / too flammable / explosive / produced from fossil fuels which leads to a net energy loss / Pt electrodes very expensive [1]

**Total [20]**

5 (a) - 705 (kJ mol<sup>-1</sup>) (1) for correct sign (1) for correct number [2]

(b) (i) ..... hydration ..... [1]  
 ..... lattice breaking [1]

(ii) e.g. add a small 'amount' of an alkali / sodium hydroxide / NaOH / OH<sup>-</sup> ions (1)  
 this would remove / react with hydrogen ions giving water, shifting the position of equilibrium to the left (removing iodine) (1)  
 add P6<sup>2+</sup> / Ag<sup>+</sup> ect. [2]

(c) (i) Any TWO from  
 white / misty fumes (of HI)  
 yellow solid / solution (of sulfur)  
 brown / black solid / purple vapour (of iodine)  
 bubbles / effervescence / fizzing  
 One mark for each correct response [2]

(ii) The values show that chlorine is the best oxidising agent, as it has the most positive E<sup>θ</sup> value and therefore iodide is the better reducing agent (1)  
 and is 'strong' enough to reduce the sulfuric acid. / OWTTE (1) [2]

(d) (i)  $2\text{NaOH} + \text{Cl}_2 \rightarrow \text{NaOCl} + \text{NaCl} + \text{H}_2\text{O}$  [1]

(ii) e.g. bleach, kills bacteria [1]

**Total [11]**

- 6 (a) Lead(II) iodide or  $PbI_2$  (1) Bright yellow (1) [2]
- (b)  $2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$  (1)
- The precipitate is copper(I) iodide (stated or clearly indicated by state symbols) (1)  
[2]
- (c) Bromine has a more positive  $E^\ominus$  than iodine so it is a stronger oxidising agent (1)
- Bromine is able to oxidise iodide (1)
- Bromine has a less positive  $E^\ominus$  than chlorine so it is a weaker oxidising agent (1)
- Bromine is not able to oxidise chloride (1)
- MAX 3
- OR Calculate EMF for each reaction (1 each) and state that positive EMF means reaction is feasible (1) [3]
- QWC Legibility of text, accuracy of spelling, punctuation and grammar, clarity of meaning* [1]
- (d) 1 mark for each two products or observations  
 $KHSO_4$  HI  $H_2S$   $SO_2$  S  $I_2$  [MAX 2 for products]
- Yellow solid rotten egg smell steamy fumes
- Black solid or brown solution or purple fumes
- MAX 3 [3]
- (e) (i) Measure time taken for a sudden colour change (1)  
 Rate =  $1 \div \text{time}$  (1) [2]
- (ii) I. pH 1 has a concentration of  $H^+$  ten times higher than pH 2. [1]
- II. Order with respect to  $H_2O_2 = 1$  (1)  
 Order with respect to  $I^- = 1$  (1)  
 Order with respect to  $H^+ = 0$  (1) [MAX 2 for the stated orders]  
 Rate =  $k[H_2O_2][I^-]$  (1) [3]
- III.  $k = 0.028$  (1)  $\text{mol}^{-1}\text{dm}^3 \text{s}^{-1}$  (1) [ecf from rate equation] [2]
- IV. Rate equation is unchanged and increasing temperature increases the value of the rate constant [1]
- Total [20]**