

M1.(a) Electron acceptor / gains electrons  
*do not allow electron pair acceptor* 1

(b) Fe<sup>2+</sup> ions 1

Fe<sup>2+</sup> / Fe or Fe<sup>2+</sup> or it has smallest / most negative electrode potential / E°  
*Do not allow Fe / Fe<sup>2+</sup>*  
*Cannot score M2 if M1 incorrect* 1

(c) Pt|H<sub>2</sub>|H<sup>+</sup>||Ag<sup>+</sup>|Ag  
*M1 for H<sub>2</sub> H<sup>+</sup> Ag<sup>+</sup> Ag in correct order* 1

allow dashed phase boundaries

2H<sup>+</sup> loses one mark (M2)  
*M2 for Pt correct and correct phase boundaries*  
*Ignore state symbols. M1 must be correct to score M2*  
*If answer correct but all in reverse order allow 1 mark out of two* 1

Any **two** correct conditions

- 298 K / 25 °C
- 100 kPa
- both solutions of unit concentration
- zero current

*Allow 1 bar*

*Do not apply list principle, mark correct answers.* 2

(d) E Au<sup>+</sup>( / Au) > E O<sub>2</sub> ( / H<sub>2</sub>O) OR e.m.f. / E<sub>cell</sub> = 0.45 V  
*If both species in electrode given, must be in correct order*  
*i.e. Au<sup>+</sup> / Au* 1

Au<sup>+</sup> (ions) oxidise water OR water reduces Au<sup>+</sup> (ions)

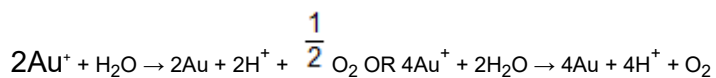
*Allow water donates electrons to Au<sup>+</sup>*

1

Gold metal / solid / precipitate **OR** bubbles / effervescence of (oxygen gas) / gas produced

*Penalise incorrect observations*

1



*Allow multiples*

1

(e) (i) 1.24 (V)

*Do not allow -1.24*

1

(ii) Chloride ions /  $\text{Cl}^-$  react with / form a precipitate with silver ions /  $\text{Ag}^+$  / form  $\text{AgCl}$

*Penalise reaction of chloride ions with iron ions or iron*

1

(f)  $E_{\text{O}_2 ( / \text{H}_2\text{O})} > E_{\text{Fe}^{3+} ( / \text{Fe}^{2+})}$  (or e.m.f /  $E_{\text{cell}} = 0.46 \text{ V}$ )

*Species in electrode if all given must be in correct order*

1

Therefore the iron(II) ions are oxidised (or converted) into iron(III) ions (by oxygen)

*If chloride ions oxidised to chlorine, lose M2*

*M2 can be obtained or lost from equation.*

*Ignore observations.*

1

[15]

**M2.(a)** Platinum electrode

1

Solution in beaker is a mixture of named soluble iron(II) compound and named soluble iron(III) compound

*Allow correct formulae for the iron compounds.*

1

Concentrations of Fe(II) and Fe(III) ions are both  $1 \text{ mol dm}^{-3}$   
*Ignore any references to temperature.*  
*If eg  $\text{Fe}_2(\text{SO}_4)_3$  used then concentration must be 0.5*

1

- (b) Purpose: Allow movement of ions between electrodes  
*Allow to maintain an electric circuit.*  
*Do not allow reference to movement of electrons in salt bridge.*

1

Requirement: Must not react with the electrolyte / ions in solution  
*Do not allow 'must not react' without further qualification.*

1

[5]

- M3.(a)** (Biocide) reacts with bacteria / used up killing bacteria  
*Max two marks*

Chlorine given off / evaporates  
*Do not allow "chlorine has reacted with water" alone.*

Chlorine has reacted with water to form (HCl and)  $\text{O}_2$   
*Do not allow products of HCl and HOCl alone*

2

- (b) the concentration of the remaining solution (after a sample has been removed) is unchanged.

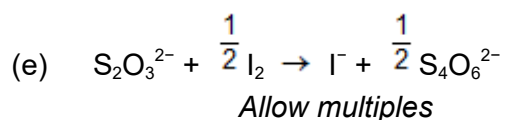
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- (c) So that all chlorine was reacted / reduced  
*Do **not** allow 'all of the iodide was oxidised'*

1

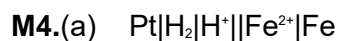
- (d) The  $E^\ominus$  value for the iodine half-equation is more positive than that for the thiosulfate  
*Allow = 0.45*  
*Must refer to values*

1



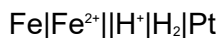
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[6]



*Allow 1 for correct order of symbols but lose second mark for a wrong phase boundary(s) / Pt missing / extra Pt on RHS, additional phase boundary*

Note, allow one mark only for correct symbol in reverse:



*Allow dashed lines for salt bridge*

*Ignore state symbols*

*Ignore 2 if used before H<sup>+</sup>*

2

(b) Electron donor

*Allow (species that) loses electrons*

*Do not allow reference to electron pairs*

1

(c) Cl<sub>2</sub> / chlorine

*If M1 blank or incorrect cannot score M2*

1

(Species on RHS / electron donor) has most positive / largest  $E^\ominus$  / has highest potential

*Do not allow reference to e.m.f. or E(cell)*

1

(d) (i) Cl / chlorine

1

- (ii) Chlorine +1 to chlorine 0  
*CE if chlorine not identified in part (i)*  
*Allow chlorine +1 to chlorine -1 (in Cl<sup>-</sup>)*  
*Allow oxidation state decreases by one OR two*  
*Allow oxidation state changes by -1 OR -2*

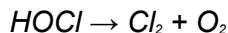
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OR



*Allow one mark for any incorrect equation that shows*



*Allow multiples*

*Ignore state symbols*

*Penalise one mark for uncanceled or uncombined species*

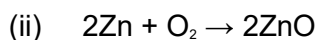
*(eg  $\text{H}_2\text{O} + \text{H}_2\text{O}$  instead of  $2\text{H}_2\text{O}$ )*

2

(f) (i) e.m.f. =  $0.40 - (-1.25) = \underline{1.65} \text{ (V)} / \underline{+1.65} \text{ (V)}$

*Allow -1.65 (V)*

1



*Allow multiples*

*Ignore state symbols*

*Do not allow uncanceled species*

*If more than one equation given, choose the best*

1

(iii) **A** / stainless lid

*If M1 incorrect or blank CE=0*

1

O<sub>2</sub> (electrode) has a more positive  $E^\ominus$  / oxygen (electrode) requires / gains electrons from external circuit

*Or reference to the overall equation and a link to electrons going into A*

*Allow oxygen is reduced and reduction occurs at the positive electrode*

OR Zinc (electrode) has more negative  $E^\ominus$   
*Do not allow reference to e.m.f. or E(cell)*

1

(iv) (Cell) reaction(s) cannot be reversed / zinc oxide cannot be reduced to zinc by passing a current through it / zinc cannot be regenerated

*Allow danger from production of gas / oxygen produced / hydrogen produced*

1

[14]

**M5.(a)** The ions in the ionic substance in the salt bridge move through the salt bridge

1

To maintain charge balance / complete the circuit

1

(b)  $F^-$

1

(c)  $E^\ominus SO_4^{2-} / SO_2$   $E^\ominus Br_2 / Br^-$

*Allow correct answer expressed in words, eg electrode potential for sulfate ions / sulfur dioxide is less than that for bromine / bromide*

1

(d) 1.23 (V)

1

(e) A fuel cell converts more of the available energy from combustion of hydrogen into kinetic energy of the car / an internal combustion engine wastes more (heat) energy

1

[6]

**M6.A**

**[1]**