Mark Scheme - 2.2 Rates of Reaction

1.

(a)		Use weighing scales to weigh the metal oxide	(1)	
		Use measuring cylinder to pour hydrogen peroxide solution and water into a conical flask	(1)	
		Immerse flask in water bath at 35 °C	(1)	
		Add oxide to flask and connect flask to gas syringe	(1)	
		Measure volume of oxygen every minute for 10 minutes / at regular time intervals	(1)	
		(any 4 of above, credit possible from labelled diagram)		[4]
(b)		Oxide **A** because reaction is faster		[1]
(c)	(i)	18 cm^3		[1]
	(ii)	10 cm^3		[1]
(d)		Concentration of hydrogen peroxide has decreased	(1)	
		reaction rate decreases / fewer successful collisions	(1)	[2]
(e)		All the hydrogen peroxide has decomposed / the same quantity of hydrogen peroxide was used		[1]
(f)		25 cm^3		[1]
(g)		Reaction will take less time	(1)	
		Reactants collide with more (kinetic) energy	(1)	
		More molecules have the required activation energy	(1)	[3]
		QWC Selection of a form and style of writing appropriate to purpose and to complexity of subject matter		[1]

Total [15]

2.

(a)	Name of any commercially/ industrially important chlorine containing compound e.g. (sodium) chlorate(I) as bleach/ (sodium) chlorate(V) as weedkiller/ aluminium chloride as catalyst in halogenation - do not accept CFCs			**[1]**
(b)	(i)	$K_c = \dfrac{[HI]^2}{[H_2][I_2]}$	must be square brackets	**[1]**
	(ii)	$K_c = \dfrac{0.11^2}{3.11^2} = 1.25 \times 10^{-3}$	follow through error (ft)	**[1]**
	(iii)	K_c has no units	ft	**[1]**
	(iv)	when temperature increases K_c increases (1) this means equilibrium has moved to RHS / increasing temperature favours endothermic reaction (1) therefore ΔH for forward reaction is +ve (1) (mark only awarded if marking point 2 given)		**[3]**
(c)	(i)	+2		**[1]**
	(ii)	co-ordinate/ dative (covalent)		**[1]**
	(iii)	pink is $[Co(H_2O)_6]^{2+}$ **and** blue is $[CoCl_4]^{2-}$ (1) (ligand is) Cl^- (1) (addition of HCl sends) equilibrium to RHS (1)		**[3]**
	(iv)	$[Co(H_2O)_6]^{2+}$ shown as octahedral [with attempt at 3D] (1) $[CoCl_4]^{2-}$ shown as tetrahedral/ square planar (1)		**[2]**

Total [14]

3.

(a)	Plotting		(2)	
	Best fit line		(1)	[3]
(b)	(i)	C	(1)	
		Curve steeper	(1)	[2]
	(ii)	Concentration of acid is greatest		[1]
(c)	$44\ cm^3$ ($\pm 1\ cm^3$)			[1]
(d)	Moles Mg = 0.101/24.3 = 0.00416		(1)	
	Moles HCl = 2 x 0.02 = 0.04		(1)	[2]
(e)	(i)	Mg is not the limiting factor / Mg now in excess / HCl not in excess		[1]
	(ii)	Moles acid = 0.5 x 0.04 = 0.02	(1)	
		Volume H_2 = 0.01 x 24 = $0.24\ dm^3$ - correct unit needed	(1)	[2]
(f)	Lower the temperature of the acid		(1)	
	Reactants collide with less energy		(1)	
	Fewer molecules that have the required activation energy (1)			[3]
or	Use pieces of magnesium (1) less surface area (1) less chance of successful collisions (1)			

QWC Selection of a form and style of writing appropriate to purpose and to complexity of subject matter. [1]

Total [16]

4.

(a) (i) They are both elements in their standard states. [1]

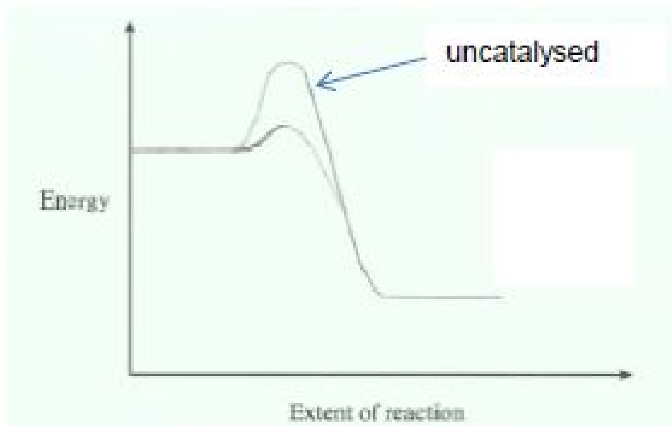
(ii) $\Delta H = \Sigma \Delta H_f$ products $- \Sigma \Delta H_f$ reactants (1)

$= (-286 + 0) - (-368 + 0)$

$= -286 + 368 = (+)82$ (kJ mol^{-1}) (1) [2]

or by a cycle where correct cycle drawn (1) correct answer (1)

(b) (i)



exothermic profile drawn (1)
uncatalysed / catalysed line labelled (1) [2]

(ii) I number of moles of benzene = 2000 [1]

II mole ratio is 1 : 1 (1)

$\therefore$ moles of phenol produced $= \frac{2000 \times 95}{100} = 1900$ (1)

mass = M_r × number of moles = 94 × 1900 = 178.6 / 179 kg (1)

alternatively

78 (g / kg) of benzene gives 94 (g / kg) of phenol (1)

$\therefore$ 1 (g / kg) of benzene gives 94/78 (g / kg) of phenol
$\therefore$ 156 (kg) of benzene gives 94 × 156/78 (kg) of phenol = 188 (kg) (1)
but 95% yield $\therefore \frac{188 \times 95}{100} = 178.6 / 179$ (kg) (1) [3]

(iii) Look for at least four relevant positive points [4]

e.g.

- the process uses a (heterogeneous) catalyst, which can easily be separated from the gaseous products (thus saving energy)
- the only other product of the reaction is gaseous nitrogen, which is non-toxic / safe / not a harmful product
- the process uses nitrogen(I) oxide which is used up, rather than being released into the atmosphere from the other process (and causing global warming)
- the process is exothermic and the heat produced can be used elsewhere
- a relatively moderate operating temperature reduces overall costs
- high atom economy

Legibility of text; accuracy of spelling, punctuation and grammar;

clarity of meaning QWC [1]

Total [14]

5.

portion to right of Ea_1 labelled as molecules that react / shaded [1]

Ea_2 marked, at lower energy than Ea_1, and portion to right labelled as molecules that react / shaded [1]

6.

(a) (i) He may have lost carbon dioxide through leaks, this would have given a lower volume than expected. (1)
He used lower concentration of acid / diluted the acid with water and the rate of carbon dioxide evolution was slower than expected. (1) [2]

(ii) The concentration of acid is higher in the first half (1) the collision rate is higher (1) [2]

(iii) eg $k = \frac{V}{T}$ (1) $\therefore k = \frac{130}{298}$ / 0.436

$\therefore V = 0.436 \times 323 = 141$ (cm^3) (1)

or $\frac{V_1}{V_2} = \frac{T_1}{T_2}$ (1) $\therefore V_1 = \frac{323 \times 130}{298} = 141$ (cm^3) (1) [2]

(b) (i) 260 (cm^3) [1]

(ii) 0.45 (g) (0.43–0.48) [1]

(c) The diagram shows two reasonable distribution curves with T_2 flatter and 'more to the right' than T_1. (1)
Activation energy correctly labelled, or mentioned in the writing (1)
Fraction of molecules having the required activation energy is much greater at a higher temperature (thus increasing the frequency of successful collisions) (in words) (1) [3]

The candidate has selected a form and style of writing that is appropriate to purpose and complexity of the subject matter QWC [1]

(d) Place the mixture on a balance and measure the (loss in) mass (1) at appropriate time intervals (1)

OR BY OTHER SUITABLE METHOD

eg. sample at intervals / quench (1) titration (1) [2]

Total [14]

7.

Provides an alternative pathway (1)
with lower activation energy / more particles have energy above E_A (1) **[2]**

8. (a) Enthalpy change when one mole of a compound is formed from its (constituent) elements (1)
in their standard states / under standard conditions (1) [2]

(b) (i) $H_2 + ½O_2 \rightarrow H_2O$ [1]

(ii) $-242 = 436 + 248 - 2(O—H)$ (1)
$2(O—H) = 926$
$O—H = 463$ kJ mol^{-1} (1) [2]

(c) (i) I. Burning hydrogen will not produce CO_2 (or SO_2) as pollutants [1]

II. Hydrogen is very flammable, storing as MgH_2 is safer / MgH_2 is solid therefore volume occupied by given amount of hydrogen is less [1]

(ii) If the MgH_2 is not kept dry, hydrogen will be formed and there could be a potential explosion [1]

(iii) Moles $MgH_2 = \frac{70000}{26.32} = 2659.6$ (2660) (1)

Moles $H_2 = 5319.2$ (5320) (1)

Volume $H_2 = 1.28 \times 10^5$ dm^3 (1) [3]

(d) (i) An increase in temperature would decrease the yield and an increase in pressure would increase the yield [1]

(ii) Forward reaction is exothermic so equilibrium shifts to the left as temperature is increased (1)

More gaseous moles on the l.h.s. so equilibrium shifts to the right as pressure is increased (1) [2]

(e) Lower temperatures can be used (1)
Energy costs saved (1)
More product can be made in a given time (so more can be sold) (1)
Enable reactions to take place that would be impossible otherwise (1)
Less fossil fuels burned to provide energy (so less CO_2 formed) (1)
(any 3 of above) [3]

QWC Legibility of text; accuracy of spelling, punctuation and grammar, clarity of meaning [1]

Total [18]

9.

(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 ÷ 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) $mol^{-1}dm^3\ s^{-1}$ (1) [ecf from rate equation] [2]

IV. Rate equation is unchanged and increasing temperature increases the value of the rate constant [1]

Total [20]

10.

(a) (a reaction in which) the rate of the forward reaction is equal to the rate of the backward reaction [1]

(b) goes darker / more brown (1)

because the (forward) reaction has a +ve ΔH / is endothermic (1)

goes paler / less brown (1)

because there are more moles / molecules on RHS (1)

no change (because catalysts do not affect the position of an equilibrium) (1) [5]

(c) (i) moles N_2H_4 = 14000/32.04 = 437.0 (1)

this produces 437.0 × 3 = 1311 moles of gas (1)

volume = 1311 × 24 = 3.15×10^4 dm^3 (1) [minimum 2 sf] [3]

(ii) (large volume of) gas produced [1]

(d) (i) an acid is a proton / H^+ donor [1]

(ii) $\rightarrow NO_2^- + H_3O^+$ [1]

(iii) sulfuric acid is behaving as the acid / nitric acid is behaving as a base (1)

as it donates a proton / as it accepts a proton (1) [2]

Total [14]