1 **(a) (i)** concentration of thiosulfate is proportional to volume of thiosulfate solution added (when total volume is same in all experiments) / concentration of acid always the same [2]

for comments based on amount / to make experiments fair / comparable allow [1]

(ii) 240 s [1]

(iii) decreases/reaction slower [1]
because concentration of thiosulfate decreases [1]
frequency/chances/rate of collisions decreases [1]

one mark can be scored for less/smaller amount/smaller volume of thiosulfate / less collisions

(b) rate increases with temperature (or at 42 °C) ORA [1]

particles/molecules/ions move faster or gain energy / ORA [1]
(don't accept reactants or atoms)

more collisions / ORA [1]

(last mark is for qualification of the collisions) i.e.
greater frequency / more per unit time/more often /greater chance/more likely/more collision rate/more effective/more successful/more with activation energy / ORA [1]

2 **(a) (i)** rate of reaction decreases / gradient decreases [1]
because concentration of bromine decreases [1]
reaction stops because all bromine is used up [1]

(ii) initial rate greater / gradient greater [1]
because bigger surface area / more particles of iron exposed [1]
or:
final mass the same [1]
because mass of bromine is the same so the same mass of iron is used [1]

(iii) increase / decrease / change rate of stirring / not stirred [1]
measure new rate / compare results [1]

(b) (i) Fe to Fe^{2+} [1]
because oxidation is electron loss / increase in oxidation number [1]

(ii) Fe [1]

(c) add sodium hydroxide solution / ammonia(aq) [1]
Fe^{2+} green precipitate [1]
Fe^{3+} brown precipitate [1]

3 **(a)** **(i)** bubbles / effervescence / hydrogen / gas pushes up / lifts metal [1]

(ii) does not react with <u>acid</u> / zinc and iron react with <u>acid</u> [1]
not just unreactive

(b) **(** with copper / first experiment [1]

(ii) copper acts as a <u>catalyst</u> [1]

(c) smaller gradient [1]
not rate is slower

(ii) same final volume of hydrogen / same level (on graph) [1]

(d) temperature / heat [1]
increase temperature – reaction faster particles have more energy **/** particles move faster / particles collide more frequently / more particles have enough energy to react
not more excited
accept arguments for a decrease in temperature [1]

powdered
greater surface area
greater collision rate / more particles exposed (to acid)
any **two** [2]
not concentration / light / catalyst / pressure

4 **(a) (i)** red brown or orange to colourless [1]
not just bromine decolourised
yellow (**not** dark) / white solid / precipitate / goes cloudy [1]
brown to yellow with no mention of solid/precipitate scores = [1]

(ii) $Br_2 + Na_2S \rightarrow 2NaBr + S$ [1]

(iii) look for two comments
sulfide (ion) / sulfur (ion) loses electrons [1]
not sodium sulfide
bromine accepts them [1]

(b) (i) oxidation [1]
not redox

(ii) hydrogen / H_2
not H [1]

(iii) iron(II) hydroxide / ferrous hydroxide [1]

(iv) $4Fe(OH)_2 + O_2 + 2H_2O \rightarrow 4Fe(OH)_3$ [1]

(v) oxidation number or state or valency increases / electron loss / Fe^{2+} to Fe^{3+} [1]
not gains oxygen

(vi) sacrificial protection **or** zinc is sacrificed /
zinc corrodes not iron **or** zinc corrodes therefore iron doesn't /
not just zinc rusts
zinc is oxidised in preference to iron /
zinc reacts with oxygen and water in preference to iron /
zinc more reactive or electropositive than iron /
zinc forms ions more readily than iron **or** zinc loses electrons more readily than iron /
electrons move on to iron /
iron is cathode **or** zinc is anode /
any **three** [3]

5 **(i)** chemical [1]

(ii) from right to left [1]
not through salt bridge

(iii) $Br_2 + 2e \rightarrow 2Br^-$ [2]
for Br- as product [1]

(iv) reduction because electron gain [1]
/ because oxidation number decreases
need both points

(v) Fe^{3+} [1]

(vi) any correct discussion of the reactivity of the halogens [1]
e.g. the more reactive the halogen the higher the volta
not better conductor

[Total: 7]