Solutions

Each answer shows the steps, then the **result**.

2.1

- adsorption of the reactants onto the surface; reaction (bonds weakened); desorption of the products

2.2

- it is in the same physical state as the reactants

3.1 B

- Reactants first adsorb onto the catalyst surface

3.2 B

- Solid iron with gaseous reactants is a heterogeneous catalyst

3.3

- reactant molecules adsorb onto the catalyst surface; this weakens their bonds and holds them close together, lowering the activation energy; the products then desorb, freeing the surface

3.4

- the Fe^{2+} is used in one step but is regenerated (reformed) in a later step, so it is not used up overall — it is a catalyst, in the same (aqueous) state as the reactants

3.5

(a)

- Reaction 1 is **heterogeneous** — the catalyst is a solid and the reactants are gases, so they are in different phases. Reaction 2 is **homogeneous** — catalyst and reactants are all in aqueous solution

(b)

- The gases **adsorb** onto the iron surface at active sites, which weakens the strong N ≡ N and H–H bonds; the adsorbed species are held close together in the right orientation, so they react; the ammonia then **desorbs**, freeing the site for more reactant

(c)

- $2Fe^{3+} + 2I^- \rightarrow 2Fe^{2+} + I_2$ and $2Fe^{2+} + S_2O_8^{2-} \rightarrow 2Fe^{3+} + 2SO_4^{2-}$. Adding them gives the overall equation with no iron in it — the catalyst is used in the first step and **regenerated** in the second, so it is not consumed. It works because both reactants are negative ions, which repel each other; Fe^{3+} offers a route via oppositely charged species

(d)

- The catalyst provides an alternative route of **lower activation energy**; on the Boltzmann distribution a larger fraction of molecules lies to the right of the new, lower E_a, so a greater proportion of collisions is successful; it lowers E_a for the forward and reverse reactions **equally**, so equilibrium is reached sooner but its position — and the yield — is unchanged