

## Answers to Exercise 10.1

### Hydrogen

1. *D is  $^2\text{H}$  (hydrogen with an extra neutron in its nucleus)*

The mass of  $\text{D}_2\text{O}$  is higher than the mass of  $\text{H}_2\text{O}$ ; however, since the extra mass is all in the nucleus, the two types of water have approximately the same volume-per-molecule. Since density is mass divided by volume, increasing mass without changing volume increases density.

2.

- (a)  $\text{H}^+$                       charge +1                       $1s^0$  (no electrons)  
(b)  $\text{H}^-$                       charge -1                       $1s^2$  (same as helium)

3.

(a)  $\text{CH}_4(g) + \text{H}_2\text{O}(g) \rightarrow \text{CO}(g) + 3\text{H}_2(g)$

*At 900-1000 °C, we expect all four species to be in the gas phase. The name “steam reformation” also implies that the water is in the gas phase.*

(b)  $\text{CO}(g) + \text{H}_2\text{O}(g) \rightarrow \text{CO}_2(g) + \text{H}_2(g)$

*At 400-500 °C, we still expect all four species to be in the gas phase.*

(c) The first step is endothermic. The second step is exothermic.

*The fact that the second step is still heated suggests that there is a significant activation energy to be overcome for this reaction to proceed.*

4.

Ionic hydrides contain  $\text{H}^-$  anions with ionic bonds to cations of Group 1 or 2 metals

e.g.  $\text{NaH}$ ,  $\text{KH}$ ,  $\text{CaH}_2$ , ...

Covalent hydrogen compounds contain H atoms covalently bonded to other atoms

e.g.  $\text{H}_2$ ,  $\text{H}_2\text{O}$ ,  $\text{CH}_4$ ,  $\text{NH}_3$ , ...

Metallic hydrides contain H atoms “dissolved” in metals (filling holes in the metal lattices)

e.g.  $\text{H}_2$  dissolved in  $\text{Ni}$ ,  $\text{Pd}$ ,  $\text{Pt}$ , ...