

## 2. This question is about capturing carbon

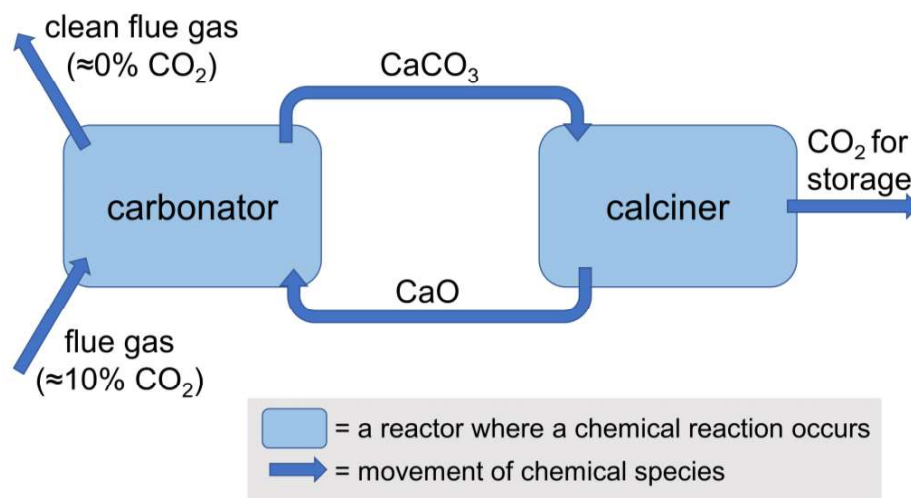
Carbon capture is a key technology for reducing greenhouse gas emissions.

One of the most promising carbon capture technologies, *calcium looping*, involves cycling between calcium carbonate and calcium oxide to capture CO<sub>2</sub>. The calcium carbonate used in this process most commonly comes from limestone.

The captured carbon dioxide can then either be stored underground or used, for example in producing synthetic fuels.



In calcium looping, CO<sub>2</sub> is captured from flue (exhaust) gases. A diagram of this cycle is shown below.



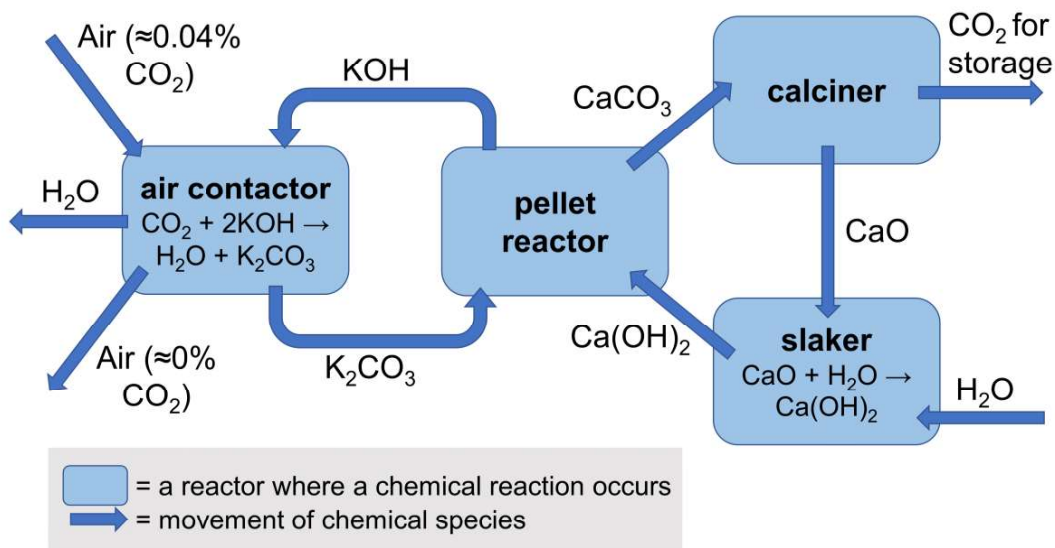
- (a) Write an equation for the main reaction in the carbonator.
- (b) Write an equation for the main reaction in the calciner.

One of the impurities in flue gases is sulfur dioxide from the combustion of sulfur-containing fuels. This can react in the carbonator to form an unreactive impurity, which can accumulate over successive cycles and reduce the efficiency of the process.

- (c) Write an equation for the formation of sulfur dioxide from the combustion of hydrogen sulfide (H<sub>2</sub>S).
- (d) Write an equation for the reaction of sulfur dioxide with calcium carbonate and oxygen to give two products.

Direct air capture is a process which takes carbon dioxide directly from the air therefore avoiding any sulfur dioxide contamination. However, this process can be expensive to run due to the energy required to overcome thermodynamic barriers.

A scheme for a direct air capture process based on calcium looping is shown below.



- (e) Write an equation for the reaction in the pellet reactor.
- (f) Calculate the standard enthalpy change for the reaction which occurs in the air contactor.

Standard enthalpy change of formations,  $\Delta_f H^\ominus$ , at 298 K in  $\text{kJ mol}^{-1}$ :

CaO	-635.1
CaCO <sub>3</sub>	-1206.9
Ca(OH) <sub>2</sub>	-986.1
KOH	-424.8
K <sub>2</sub> CO <sub>3</sub>	-1151.2
CO <sub>2</sub>	-393.5
H <sub>2</sub> O	-285.8

- (g) Tick the correct statement that describes the standard enthalpy change at 298 K for the sum of the reactions in the four reactors.
- (h) Tick the two correct statements about the entropy changes in this process.