



PART 1

Read the text below and answer questions 1–13.

DIRECT AIR CAPTURE: PULLING CARBON FROM THE SKY

Direct air capture (DAC) refers to a family of technologies designed to remove carbon dioxide directly from ambient air. The concept resembles “carbon capture” at factories, but the engineering problem is fundamentally different. At a point source such as a cement plant or power station, CO_2 concentrations in exhaust gases can reach around 10% (or higher), so capture systems work on a relatively rich stream. In open air, by contrast, CO_2 is present in much lower concentrations—roughly 400 parts per million—meaning that a DAC facility must process vast volumes of air to collect the same mass of gas. This dilution drives the scale of the equipment, the need for large contactors and fans, and the tight accounting used to judge performance: the key metric is not what a machine captures, but what it removes after its own energy use is considered.

In most designs, air is drawn through contactors by large fans, and carbon dioxide is selectively bound by a capture medium while nitrogen, oxygen, and water vapour pass through. Two approaches dominate. The first uses solid sorbents, sometimes described as “filters,” which are coated with chemicals that have an affinity for CO_2 . The second uses liquid solvents, which treat air as a feedstock for a chemical reaction in a circulating solution. Both approaches share the same logic—capture and then regeneration—but they differ in operating temperatures, equipment layout, and the form in which carbon is handled during processing.

Solid-sorbent systems typically rely on porous materials coated with amines. As air flows across the surface, CO_2 molecules attach to the amine sites through adsorption, gradually filling the available binding capacity. Once the sorbent is saturated, the system switches to a regeneration phase. Instead of capturing more air, the contactor is isolated and the sorbent is exposed to low-grade heat, a pressure change, or steam. This desorption releases CO_2 as a concentrated stream that can be dried, compressed, and transported. The appeal of solid systems is that they can operate at comparatively modest temperatures, making it possible—at least in principle—to pair them with low-carbon heat sources. However, the cycling between adsorption and desorption imposes engineering demands: valves, seals, and heating systems must operate reliably, and any leakage or uneven heating can reduce capture efficiency.

Liquid-solvent systems take a different route, often using strongly alkaline solutions. Air is brought into contact with the liquid, and CO_2 reacts chemically to form carbonate compounds. In one common industrial configuration, the captured carbon is transferred



through a series of steps that ultimately produce calcium carbonate pellets. These pellets are then heated in a high-temperature unit to release purified CO₂ and regenerate the capture materials. Because the regeneration step requires substantial heat, some designs historically paired the process with natural gas, using combustion to reach the temperatures needed for calcination. This raises a crucial issue for climate accounting: if fossil energy is used to run the system, the facility can end up emitting a significant fraction of the CO₂ it captures. For this reason, modern proposals emphasise electrification, waste heat, or other low-carbon heat sources, and they evaluate systems in terms of net removal rather than gross capture.

Energy, in fact, is not an optional detail but the central constraint. Separating a dilute gas from a mixture is governed by the laws of thermodynamics: the lower the concentration, the more work is required to isolate a pure stream. DAC therefore faces an intrinsic “energy penalty,” even before practical losses in fans, pumps, and compressors are counted. Supporters argue that the penalty can be reduced through better materials, improved airflow design, and heat integration, while critics point out that large-scale deployment would still require enormous supplies of clean electricity and heat. If a region must build additional renewable capacity mainly to power DAC, the opportunity cost becomes significant: that electricity might otherwise have displaced fossil generation directly.

After capture, carbon dioxide can follow two broad pathways: storage or use. Carbon sequestration aims for long-term isolation of CO₂, usually by injecting it deep underground into suitable geological formations. Some projects target basalt rocks, where CO₂ can react with minerals and become solid carbonates through mineralisation, reducing the risk of future release. Storage, however, is not merely a technical act; it requires monitoring, long-term responsibility, and credible measurement, reporting, and verification systems. Public trust can be fragile if communities fear leakage, industrialisation, or an unequal distribution of risks and benefits.

Carbon utilisation uses CO₂ as an input to manufacture products. The most frequently discussed examples are synthetic fuels, including synthetic jet fuel, where captured CO₂ is combined with hydrogen to create hydrocarbons. In such cases, DAC can contribute to a closed carbon cycle if the fuel displaces fossil fuel and if the energy inputs are low carbon. Yet utilisation does not always equal removal. Fuels release CO₂ when burned, meaning that the climate value depends on what emissions are avoided elsewhere and whether the process genuinely reduces net additions to the atmosphere.

Cost and policy debates therefore surround DAC as much as chemistry does. DAC plants require large equipment, specialised materials, and steady energy supplies, making



current costs high compared with many direct emissions-cutting measures. Proponents claim that costs could fall through learning-by-doing and mass manufacturing, much as solar panels declined in price over time. Opponents warn of moral hazard: if policymakers and companies treat future removal as an excuse to delay decarbonisation today, cumulative emissions may rise and society may become dependent on a technology that is difficult to scale quickly. The most cautious view treats DAC as a potential complement—useful for hard-to-abate emissions and for drawing down residual CO₂—rather than as a substitute for cutting emissions at source.

Questions 1–7

Choose **TRUE** if the statement agrees with the information given in the text, choose **FALSE** if the statement contradicts the information, or choose **NOT GIVEN** if there is no information on this.

- 1 The passage contrasts DAC with point-source capture by noting that factory exhaust contains a much higher concentration of CO₂ than ambient air.
- 2 The passage states that solid-sorbent DAC systems capture CO₂ mainly by dissolving it in an alkaline liquid.
- 3 The passage indicates that regenerating solid sorbents may involve low-grade heat or steam.
- 4 The passage suggests that some liquid-solvent DAC designs have used natural gas to provide the high temperatures required for regeneration.
- 5 The passage claims that DAC can avoid thermodynamic energy penalties because it captures CO₂ directly from open air.
- 6 The passage describes basalt storage as a method where CO₂ can undergo mineralisation over time.
- 7 The passage provides exact figures for how much government funding DAC receives in different countries.

Questions 8–13

Complete the summary below. Choose **ONE WORD ONLY** from the text for each answer.

The Direct Air Capture Process

To function effectively, DAC facilities must process enormous volumes of air because carbon dioxide exists in relatively low **8** in the atmosphere. Air is pulled through large **9**, where CO₂ is selectively captured. In solid-sorbent systems, CO₂ binds



to chemicals called **10** on a porous surface. During regeneration, captured CO₂ can be freed using low-grade heat or **11**; changing the pressure provides another option. In liquid systems, chemical reactions can form calcium carbonate **12**, which are later heated to release CO₂. The captured CO₂ may be injected for long-term storage in **13** rocks, where mineralisation can occur.

Answer Key

1. TRUE
2. FALSE
3. TRUE
4. TRUE
5. FALSE
6. TRUE
7. NOT GIVEN
8. concentrations
9. contactors
10. amines
11. steam
12. pellets
13. basalt