

Counter-Current Principle in Industrial Processes

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Response: Analyzing each process to determine if the **counter-current principle** (opposite directions of flow for contacting streams) is utilized:

1. **(a) Production of NaOH by the membrane cell method:** In a modern membrane cell, purified brine (NaCl) flows through the anode compartment while water/dilute NaOH flows through the cathode compartment. The flows are typically parallel or simply cross-flow through adjacent compartments across a cation-exchange membrane, rather than employing a counter-current setup.
2. **(b) Extraction of Fe by a blast furnace: Utilizes counter-current principle.** Solid raw materials (iron ore, coke, and limestone) are fed from the top of the furnace and descend, while preheated hot air/gases blast upwards from the bottom (tuyères). This provides highly efficient heat exchange and gas-solid reactions.
3. **(c) Production of H_2SO_4 by the Contact process: Utilizes counter-current principle.** In the absorption tower (packed tower), SO_3 gas enters at the bottom and flows upward, while concentrated sulfuric acid (98%) is sprayed from the top and flows downward.
4. **(d) Production of NH_3 by the Haber-Bosch process:** The synthesis loop involves passing a mixture of N_2 and H_2 gas across a fixed bed catalyst (parallel flow through the reaction beds), followed by cooling to condense ammonia; it does not rely on counter-current flow.

Analysis Summary

- **(b)** and **(c)** utilize counter-current flow.
- **(a)** and **(d)** do not.

According to standard G.C.E. A/L multiple-choice response options for statement combinations:

- **(b) and (c) only** are correct (Option **2** or **B**, depending on the paper's key format).
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