Which Model Fits?

Compare acid-base definitions across three reactions

CHE.9.4 "Enrichment: Analyze and evaluate the Arrhenius, Bronsted-Lowry, and Lewis acid-base definitions."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline each model's defining change, circle each mention of water or a dry setting, and number the three container cases so you can compare which models apply.

Three Containers, Three Models

1. Chemists use three acid-base models because different reactions reveal different kinds of change. In the Arrhenius model, an acid increases H_3O^+ in water, and a base increases OH^- in water. The water requirement matters: a reaction in a dry container is outside this model's scope. In the Brønsted-Lowry model, an acid donates a proton, H^+, and a base accepts one. A Lewis acid accepts an electron pair, while a Lewis base donates an electron pair. A single reaction can fit more than one model, but fitting a broader model does not erase the details that a narrower model reveals.

2. Consider two containers. In the first, hydrogen chloride dissolves in water: $HCl + H_2O \rightarrow H_3O^+ + Cl^-$. A proton leaves HCl and joins a water molecule. The water molecule uses a lone pair to bond to that proton; the electrons from the original HCl bond move to chlorine. In the second container, dry HCl gas meets dry NH_3 gas, producing solid NH_4Cl. A proton moves from HCl to NH_3 even though there is no liquid water. The nitrogen in NH_3 supplies an electron pair to make its new bond.

3. Now picture a third container holding dry boron trifluoride, BF_3, and ammonia, NH_3. The boron atom can accept an electron pair, and nitrogen has a lone pair to donate. They form a bond in $BF_3{\cdot}NH_3$, with no proton transferred and no water present. This case tests whether a model can describe bond formation without any change in proton ownership. When comparing models, ask what changes, which particles cause it, and whether the setting meets the model's conditions. A model that covers more cases is useful, but the most detailed explanation depends on the question you want to answer.

2 ANSWER WITH EVIDENCE

Use the passage

1. In the first container, why does HCl qualify as an acid under both the Arrhenius and Brønsted-Lowry models?

2. Why can the reaction in the second container be described by the Brønsted-Lowry and Lewis models, but not the Arrhenius model?

3. Which model describes the reaction in the third container? Explain why the other two models do not apply.

4. Which model can describe all three containers? What distinction would you lose if you used only that model?

3 YOUR TURN

Your own words

In a dry flask, $AlCl_3$ accepts a lone pair from Cl^- to form $AlCl_4^-$. In three or four sentences, identify the acid and base under the model that applies, explain why the other models do not apply, and judge which model is most useful here.

Which Model Fits?

PART 1 · READ AND MARK

Underline each model's defining change, circle each mention of water or a dry setting, and number the three container cases so you can compare which models apply. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	In the first container, why does HCl qualify as an acid under both the Arrhenius and Brønsted-Lowry models?	**HCl increases H_3O^+ in water, meeting the Arrhenius definition, and donates a proton to H_2O, meeting the Brønsted-Lowry definition.**
2	Why can the reaction in the second container be described by the Brønsted-Lowry and Lewis models, but not the Arrhenius model?	**HCl donates a proton to NH_3, whose nitrogen donates an electron pair to form a bond to that proton. The reaction occurs without water, so the Arrhenius model does not apply.**
3	Which model describes the reaction in the third container? Explain why the other two models do not apply.	**The Lewis model applies: BF_3 accepts an electron pair from NH_3. No proton transfers, so the Brønsted-Lowry model does not apply, and no water is present for the Arrhenius model.**
4	Which model can describe all three containers? What distinction would you lose if you used only that model?	**The Lewis model describes all three through electron-pair donation and acceptance. Used alone, it would not distinguish reactions that transfer protons or meet the Arrhenius model's water requirement.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

The Lewis model applies: $AlCl_3$ is the acid because it accepts an electron pair, and Cl^- is the base because it donates one. The Brønsted-Lowry model does not apply because no proton transfers. The Arrhenius model does not apply because the reaction occurs without water. The Lewis model is most useful here because it explains the new bond through electron-pair donation.

Accept equivalent explanations that identify the particle donating or accepting a proton or electron pair. Do not require students to name an Arrhenius base in the first container.