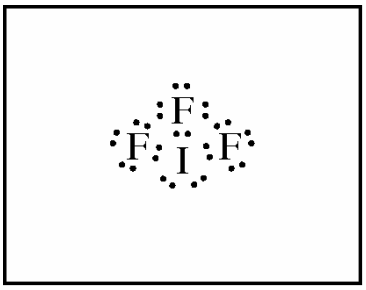
AP® CHEMISTRY
2007 SCORING GUIDELINES

Question 6

Answer the following questions, which pertain to binary compounds.

(a) In the box provided below, draw a complete Lewis electron-dot diagram for the IF_3 molecule.

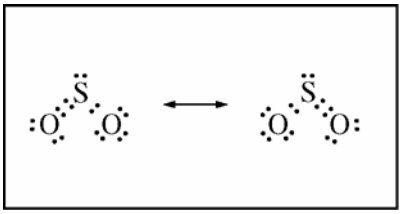


One point is earned for a correct Lewis diagram (can be done with dots or lines).

(b) On the basis of the Lewis electron-dot diagram that you drew in part (a), predict the molecular geometry of the IF_3 molecule.

T-shaped	One point is earned for the molecular geometry consistent with the Lewis diagram in part (a).

(c) In the SO_2 molecule, both of the bonds between sulfur and oxygen have the same length. Explain this observation, supporting your explanation by drawing in the box below a Lewis electron-dot diagram (or diagrams) for the SO_2 molecule.



One point is earned for a correct diagram (can be done with dots or lines). One point is earned for some indication or discussion of resonance (but the point is <u>not</u> earned for a description of resonance as a dynamic process). **OR**	
$\overline{\underline{O}}=\overline{S}=\overline{\underline{O}}$ The bonds are the same length because they are both double bonds.	One point is earned for a correct diagram (can be done with dots or lines). One point is earned for stating that both bonds are double bonds.

Question 6 (continued)

(d) On the basis of your Lewis electron-dot diagram(s) in part (c), identify the hybridization of the sulfur atom in the SO_2 molecule.

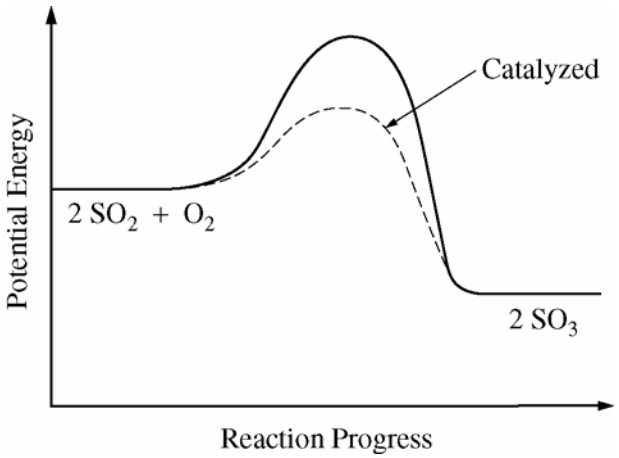
sp^2	One point is earned for hybridization consistent with part (c).

The reaction between $SO_2(g)$ and $O_2(g)$ to form $SO_3(g)$ is represented below.

$$2\ SO_2(g) + O_2(g) \rightleftarrows 2\ SO_3(g)$$

The reaction is exothermic. The reaction is slow at 25°C; however, a catalyst will cause the reaction to proceed faster.

(e) Using the axes provided below, draw the complete potential-energy diagram for both the catalyzed and uncatalyzed reactions. Clearly label the curve that represents the catalyzed reaction.



One point is earned for an uncatalyzed reaction curve that must show that $E_a > 0$ and $\Delta H < 0$.

One point is earned for a catalyzed reaction curve that must show $E_a <$ uncatalyzed E_a, must be clearly labeled, and must begin and end at the same energies as the uncatalyzed curve.

Question 6 (continued)

(f) Predict how the ratio of the equilibrium pressures, $\frac{p_{SO_2}}{p_{SO_3}}$, would change when the temperature of the uncatalyzed reaction mixture is increased. Justify your prediction.

The ratio $\frac{p_{SO_2}}{p_{SO_3}}$ would increase as the temperature increases. Because the reaction is exothermic ($\Delta H < 0$), as the temperature is raised the reaction shifts to the left.	One point is earned for the correct answer and explanation.

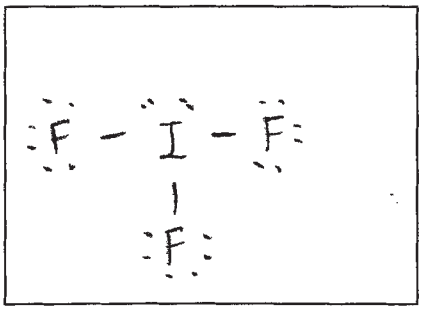
(g) How would the presence of a catalyst affect the change in the ratio described in part (f)? Explain.

The catalyst would not affect the value of the two equilibrium ratios but would increase the rate of the shifting of the system to the new equilibrium position. The catalyst does this by providing an alternate path with a lower activation energy.	One point is earned for the correct answer and explanation.

6A,

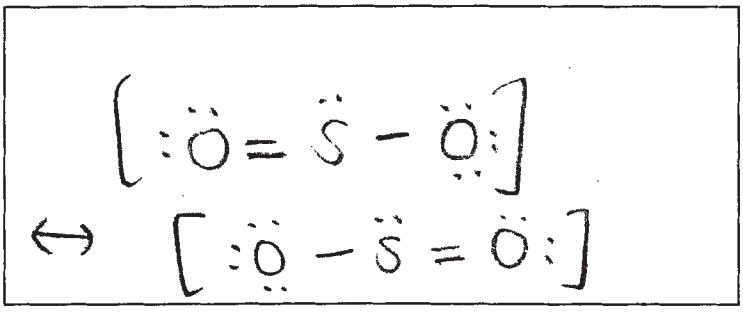
6. Answer the following questions, which pertain to binary compounds.

(a) In the box provided below, draw a complete Lewis electron-dot diagram for the IF_3 molecule.



(b) On the basis of the Lewis electron-dot diagram that you drew in part (a), predict the molecular geometry of the IF_3 molecule.

(c) In the SO_2 molecule, both of the bonds between sulfur and oxygen have the same length. Explain this observation, supporting your explanation by drawing in the box below a Lewis electron-dot diagram (or diagrams) for the SO_2 molecule.



(d) On the basis of your Lewis electron-dot diagram(s) in part (c), identify the hybridization of the sulfur atom in the SO_2 molecule.

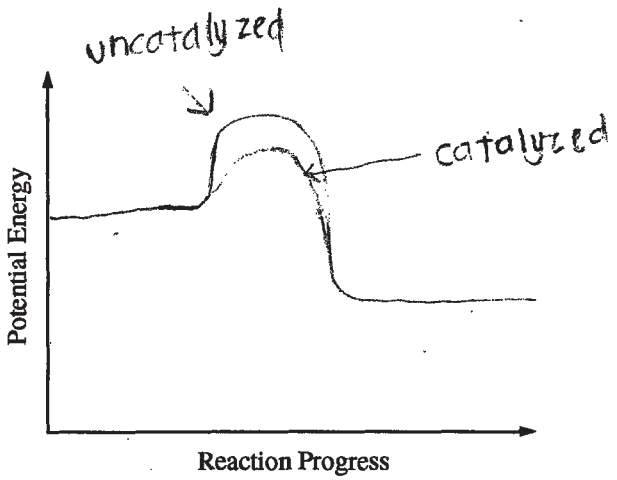
The reaction between $SO_2(g)$ and $O_2(g)$ to form $SO_3(g)$ is represented below.

$$2\,SO_2(g) + O_2(g) \rightleftarrows 2\,SO_3(g)$$

The reaction is exothermic. The reaction is slow at 25°C; however, a catalyst will cause the reaction to proceed faster.

(e) Using the axes provided on the next page, draw the complete potential-energy diagram for both the catalyzed and uncatalyzed reactions. Clearly label the curve that represents the catalyzed reaction.

B B B B B B B B B B B B B 6A2



(f) Predict how the ratio of the equilibrium pressures, $\frac{p_{SO_2}}{p_{SO_3}}$, would change when the temperature of the uncatalyzed reaction mixture is increased. Justify your prediction.

(g) How would the presence of a catalyst affect the change in the ratio described in part (f)? Explain.

b T-shaped
c Both of the bonds have the same length because the SO_2 molecule displays resonance so, the length of the SO_2 bonds are both equal. The length is between the length of a single bond and that of a double bond
d. sp^2 hybridization
f. When the temperature is increased the reaction goes towards the endothermic direction in this reaction. it would then head towards the left, causing more of SO_2 and O_2 to be produced. With more SO_2, the pressure of SO_2 would be higher and ~~$\frac{P_{SO_2}}{P_{SO_3}}$~~ would then be greater
g The presence of a catalyst would not change this ratio because a catalyst only lowers the activation energy.

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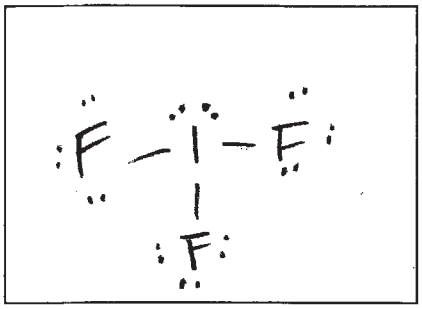
6B1

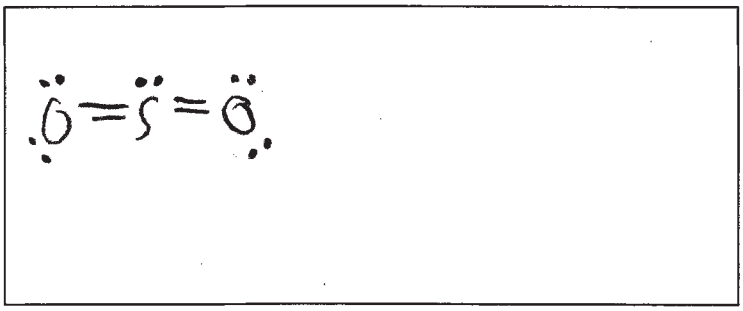
6. Answer the following questions, which pertain to binary compounds.

(a) In the box provided below, draw a complete Lewis electron-dot diagram for the IF_3 molecule.



(b) On the basis of the Lewis electron-dot diagram that you drew in part (a), predict the molecular geometry of the IF_3 molecule.

(c) In the SO_2 molecule, both of the bonds between sulfur and oxygen have the same length. Explain this observation, supporting your explanation by drawing in the box below a Lewis electron-dot diagram (or diagrams) for the SO_2 molecule.



(d) On the basis of your Lewis electron-dot diagram(s) in part (c), identify the hybridization of the sulfur atom in the SO_2 molecule.

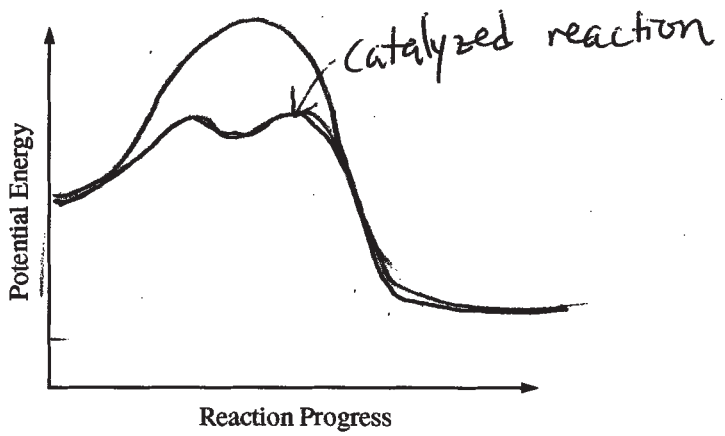
The reaction between $SO_2(g)$ and $O_2(g)$ to form $SO_3(g)$ is represented below.

$$2\ SO_2(g) + O_2(g) \rightleftarrows 2\ SO_3(g)$$

The reaction is exothermic. The reaction is slow at 25°C; however, a catalyst will cause the reaction to proceed faster.

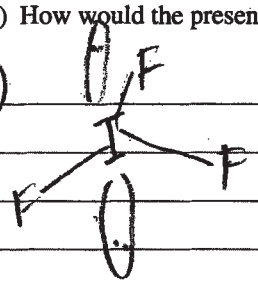
(e) Using the axes provided on the next page, draw the complete potential-energy diagram for both the catalyzed and uncatalyzed reactions. Clearly label the curve that represents the catalyzed reaction.

6B2



(f) Predict how the ratio of the equilibrium pressures, $\frac{p_{SO_2}}{p_{SO_3}}$, would change when the temperature of the uncatalyzed reaction mixture is increased. Justify your prediction.

(g) How would the presence of a catalyst affect the change in the ratio described in part (f)? Explain.

b)  trigonal planar

c) both bonds have the same length because they are both double bonds.

d) sp^3d

f) the ratio will increase because the rxn is exothermic, so adding heat will shift the rxn to the left. (Le Chatelier)

g) The catalyst will not affect the change because it only affects the rate.

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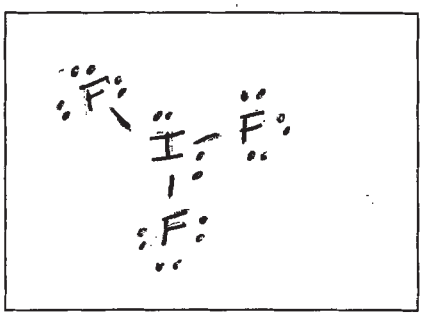
6C,

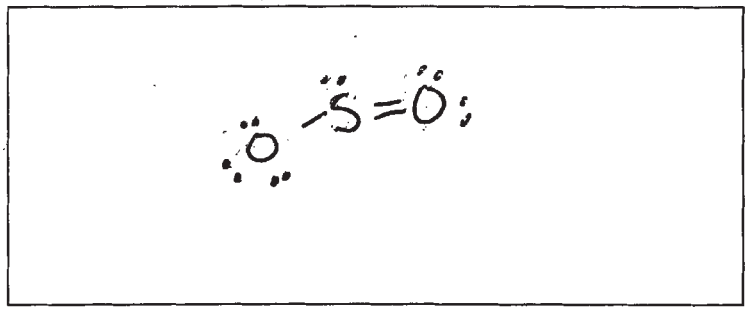
6. Answer the following questions, which pertain to binary compounds.

(a) In the box provided below, draw a complete Lewis electron-dot diagram for the IF_3 molecule.



(b) On the basis of the Lewis electron-dot diagram that you drew in part (a), predict the molecular geometry of the IF_3 molecule.

(c) In the SO_2 molecule, both of the bonds between sulfur and oxygen have the same length. Explain this observation, supporting your explanation by drawing in the box below a Lewis electron-dot diagram (or diagrams) for the SO_2 molecule.



(d) On the basis of your Lewis electron-dot diagram(s) in part (c), identify the hybridization of the sulfur atom in the SO_2 molecule.

The reaction between $SO_2(g)$ and $O_2(g)$ to form $SO_3(g)$ is represented below.

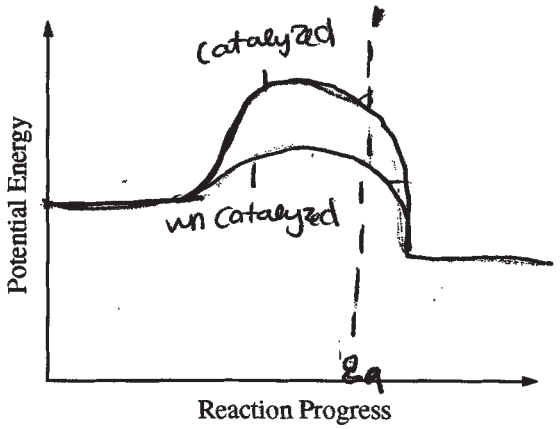
$$2\,SO_2(g) + O_2(g) \rightleftarrows 2\,SO_3(g)$$

The reaction is exothermic. The reaction is slow at 25°C; however, a catalyst will cause the reaction to proceed faster.

(e) Using the axes provided on the next page, draw the complete potential-energy diagram for both the catalyzed and uncatalyzed reactions. Clearly label the curve that represents the catalyzed reaction.

GO ON TO THE NEXT PAGE.

B B B B B B B B B B B B B $6C_2$



(f) Predict how the ratio of the equilibrium pressures, $\frac{p_{SO_2}}{p_{SO_3}}$, would change when the temperature of the uncatalyzed reaction mixture is increased. Justify your prediction.

(g) How would the presence of a catalyst affect the change in the ratio described in part (f)? Explain.

B) molecular geometry = square planar

C) They are the same length because the geometry is bent bringing the bonded atoms closer to the central atom

D) sp^2

F) The ratio would ~~in~~ decrease because the reaction would shift right to burn off the added heat causing the amount of SO_3 to increase and the amount of SO_2 to decrease

G) A catalyst would not affect this change.

GO ON TO THE NEXT PAGE.

AP® CHEMISTRY
2007 SCORING COMMENTARY

Question 6

Overview

Parts (a) though (d) of this question probed students' understanding of bonding models for simple binary compounds. Students needed to be familiar with Lewis electron-dot diagrams, the valence shell electron pair repulsion model, and valence bond theory (hybridization). Parts (e), (f), and (g) tested students' understanding of the factors that affect chemical reactions and required them to combine thermodynamic and kinetic factors in their arguments.

Sample: 6A
Score: 8

This response earned 8 out of 9 points: 1 for part (a), 1 for part (b), 2 for part (c), 1 for part (d), 2 for part (e), and 1 for part (f).

Sample: 6B
Score: 6

The point was earned in part (a). The point was not earned in part (b). In part (c) the Lewis diagram of SO_2 has 18 electrons with an expanded shell of electrons around the central S atom. This structure is not the preferred answer, but it does lower the formal charge on each atom to zero and some sulfur compounds do have expanded octets, so this answer earned 1 point. The statement "they are both double bonds" succinctly indicates why the two S-O bonds are the same length and earned the second point for part (c). The proposed hybridization of the sulfur atom, sp^3d, did not earn a point for part (d). Both points were earned in part (e); the valley in the curve for the catalyzed path (suggesting an intermediate in the catalyzed path) is acceptable. The point was earned in part (f). The answer to part (g) does not clearly address the question and did not earn a point.

Sample: 6C
Score: 4

The point was earned in part (a). The point was not earned in part (b). The correct Lewis diagram for one of the resonance forms of SO_2 earned 1 point for part (c), but the explanation, based on a bent geometry, is incorrect and did not earn the second point. The point was earned in part (d). The curve for the uncatalyzed reaction has an activation energy and represents an exothermic reaction, so this curve earned 1 point in part (e). However, the catalyzed reaction curve shows a greater activation energy than the curve representing the uncatalyzed path, so the second point was not earned. The answer to part (f) predicts the wrong change in the ratio and makes an invalid argument to support the prediction, so the point was not earned. In part (g) the student does not really address the question, so the point was not earned.