17. The equilibrium is: $N_2O_3(g) \rightleftharpoons NO(g) + NO_2(g)$

(a) increase the [NO]

(b) increase the $[N_2O_3]$

(c) increase the pressure by decreasing the volume

(d) add a catalyst

18. The equilibrium is: $2H_2(g) + 2\ NO(g) \rightleftharpoons N_2(g) + 2\ H_20(g)$

(a) decrease the $[N_2]$

(b) decrease the [NO]

(c) decrease the pressure by increasing the volume

19. The equilibrium is: $2\ CO(g) + O_2(g) \rightleftharpoons 2\ CO_2(g) + 566\ kJ$

(a) increase the temperature

(b) increase the [O2]

(c) introduce a catalyst

20. The equilibrium is: $l_2(g) + Cl_2(g) \rightleftharpoons 2\ lCl(g)$; $\Delta H = 35.0$ kJ.

(a) decrease the temperature

(b) decrease the $[Cl_2]$

(c) increase the pressure by decreasing the volume

For each of Exercises 21 23, describe the effect on the concentration of the bold substance by following changes. Write INC for increase, DEC for decrease or NC for no change.

21. The equilibrium is: $N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$; ΔH = -92 kJ.
    (a) increase the $[N_2]$

    (b) increase the temperature

    (c) increase the volume

    (d) add a catalyst

22. The equilibrium is: $2HF\ (g) \rightleftharpoons F_2(g) + H_2(g)$; ΔH = 536 kJ.
    (a) decrease the temperature

    (b) increase the $[H_2]$

    (c) increase the volume

23. equilibrium is: $SnO_2(s) + 2\ CO(g) \rightleftharpoons Sn(s) + 2\ CO_2(g)$; $\Delta H = 13$ kJ.

(a) increase the temperature

(b) add a catalyst

(c) increase the [CO]

NOTE: In Exercises 24-26 the relative positioning of the molecules is not relevant; simply place them on the graph so the reactants are separated from the products. The Only thing required here is to show what an individual substance's concentration does after the conditions change.

24. The equilibrium is: $H_2(g) + l_2(g) \rightleftharpoons 2\ Hl(g) + 52$ kJ

(a) increase the temperature

(b) inject some $H_2(g)$

(c) decrease the volume

(d) add a catalyst

25. The equilibrium is: $2SO_2(g) + O_2(g) \rightleftharpoons 2\ SO_3(g)$; ΔH = -197 kJ.

(a) inject some $SO_2(g)$

(b) increase the volume

(c) decrease the temperature

(d) increase the $[SO_3]$

26. The equilibrium is: $CO(g) + H_2O(g) \rightleftharpoons CO_2(g) + H_2(g)$; ΔH = -41 kJ.

(a) inject some $CO_2(g)$

(b) remove some of the $H_2O(g)$ with a very rapidly acting drying agent

(c) increase the temperature

(d) decrease the pressure by increasing the volume

Interpret the following graphs in terms of the changes which must have been imposed on the equilibrium.

27. The equilibrium is: $PCl_5(g) + 92.5\text{ kJ} \rightleftharpoons PCl_3(g) + Cl_2(g)$

28. The equilibrium is: $H_2O(g) + Cl_2O(g) \rightleftharpoons 2\ HOCl(g) + 70\text{ kJ}$

29. $N_2(g) + 3\ H_2(g) \rightleftharpoons 2NH_3(g) + 92$ kJ.

(a) In order to get highest yield of $NH_3(g)$, should you use high or low pressure?

(b) In order to get the the highest yield of $NH_3(g)$, should you use high or low temperature?

(c) In order to have the fastest reaction rate, should you use high or low temperature?

(d) Look at your answers to parts (b) and (c). What problem now exists? Suggest a suitable way to resolve this problem.

(e) What else can be done to speed up the reaction rate? (Industry uses iron oxide for this purpose, in the form of ground up, rusted automobile bodies.)

30. $CaCO_3(s) + 175$ kJ $\rightleftharpoons CaO(s) + CO_2(g)$

(a) Should high or low temperatures be used to get the greatest yield of CaO?

(b) Should high or low pressures be used to get the highest yield of CaO? How would you accomplish this in actual practice?

(c) Should high or low temperatures be used to obtain the fastest reaction rate? Is there a conflict between the answers for parts (a) and (c)?