Chemical Reactions

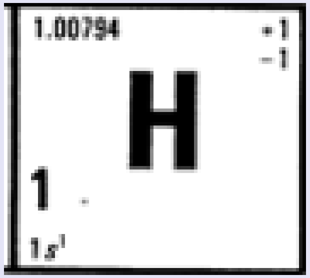
Practice Questions

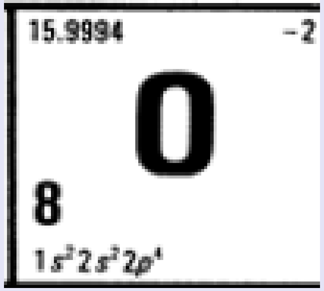
The Mass of a Mole of a Compound

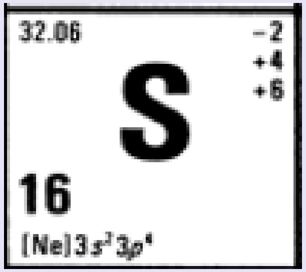
Molar Mass

To find the molar mass of a compound, add the atomic masses of the atoms that make up the molecule.

A molecule of H_3PO_4 is composed of three Hydrogen atoms, one Phosphorus atom, and four of oxygen atoms (*round masses*).







H_2SO_3					
Atom	# atoms in Formula	x	Atomic Mass	=	Total Mass of Element
H					
S					
O					

TRY IT

The Mass of a Mole of a Compound

Molar Mass

To find the molar mass of a compound, add the atomic masses of the atoms that make up the molecule.

A molecule of H_3PO_4 is composed of three Hydrogen atoms, one Phosphorus atom, and four of oxygen atoms (*round masses*).

H_2SO_3					
Atom	# atoms in Formula		Atomic Mass		Total Mass of Element
H	2		1		2
S	1	x	32	=	32
O	3		16		48
					82 amu

TRY IT

1 mol of H_2SO_3 has a mass of 82 g.

This is the mass of 6.02×10^{23} molecules of H_2SO_3 .

$SiO_2(s) + HF(g) \rightarrow SiF_4(g) + H_2O(l)$

Is this **skeleton** equation of a chemical reaction balanced? If not, balance it.

TRY IT

$$SiO_2(s) + HF(g) \rightarrow SiF_4(g) + H_2O(l)$$

This **skeleton** equation of a chemical reaction is NOT balanced:

1 Si → 1 Si … 2 O → 1 O … 1 H → 2 H … 1 F → 4 F

TRY IT

Therefore, use coefficients to balance the equation:

$$1SiO_2(s) + \mathbf{4}HF(g) \rightarrow 1SiF_4(g) + \mathbf{2}H_2O(l)$$

Inspect:

1 Si → 1 Si … 2 O → **2** O … **4** H → 4 H … **4** F → 4 F

State what type of reaction the following are:

Aluminum + Copper (II) sulfate → Aluminum Sulfate + Copper

$2\ Al^{0}$ + $3\ Cu^{+2}(S^{+6}O_4^{-2})^{-2}$ → $Al_2^{+3}(S^{+6}O_4^{-2})_3^{-2}$ + $3\ Cu^{0}\ _{(g)}$

Aluminum sulfate + Calcium hydroxide → Aluminum hydroxide + Calcium sulfate

$Al_2^{+3}(S^{+6}O_4^{-2})_3^{-2}$ + $3\ Ca^{+2}(O^{-2}H^{+1})_2^{-1}$ → $2\ Al^{+3}(O^{-2}H^{+1})_3^{-1}\ _{(s)}$ + $3\ Ca^{+2}(S^{+6}O_4^{-2})^{-2}$

Calcium Chlorite → Calcium chloride + Oxygen

$Ca^{+2}(Cl^{+3}O_2^{-2})_2^{-1}$ → $Ca^{+2}Cl_2^{-1}$ + $2\ O_2^{0}\ _{(g)}$

Potassium oxide + Carbon (IV) oxide → Potassium Carbonate

$K_2^{+1}O^{-2}$ + $C^{+4}O_2^{-2}$ → $K_2^{+1}(C^{+4}O_3^{-2})^{-2}$

$2\ C_2^{-3}H_6^{+1}$ + $7\ O_2^{0}$ → $4\ C^{+4}O_2^{-2}$ + $6\ H_2^{+1}O^{-2}$

Ethane + Oxygen → Carbon dioxide + water

State what type of reaction the following are:

TRY IT

Aluminum + Copper (II) sulfate → Aluminum Sulfate + Copper

$2\ Al^{0}$ + $3\ Cu^{+2}(S^{+6}O_4^{-2})^{-2}$ → $Al_2^{+3}(S^{+6}O_4^{-2})_3^{-2}$ + $3\ Cu^{0}\ _{(g)}$

Single Replacement (Al metal replace Cu metal)

Aluminum sulfate + Calcium hydroxide → Aluminum hydroxide + Calcium sulfate

$Al_2^{+3}(S^{+6}O_4^{-2})_3^{-2}$ + $3\ Ca^{+2}(O^{-2}H^{+1})_2^{-1}$ → $2\ Al^{+3}(O^{-2}H^{+1})_3^{-1}\ _{(s)}$ + $3\ Ca^{+2}(S^{+6}O_4^{-2})^{-2}$

Double Replacement (metal cations exchange)

Calcium Chlorite → Calcium chloride + Oxygen

$Ca^{+2}(Cl^{+3}O_2^{-2})_2^{-1}$ → $Ca^{+2}Cl_2^{-1}$ + $2\ O_2^{0}\ _{(g)}$

Decomposition (ONE reactant)

Potassium oxide + Carbon (IV) oxide → Potassium Carbonate

$K_2^{+1}O^{-2}$ + $C^{+4}O_2^{-2}$ → $K_2^{+1}(C^{+4}O_3^{-2})^{-2}$

Synthesis (ONE product)

$2\ C_2^{-3}H_6^{+1}$ + $7\ O_2^{0}$ → $4\ C^{+4}O_2^{-2}$ + $6\ H_2^{+1}O^{-2}$

Ethane + Oxygen → Carbon dioxide + water

Combustion (oxygen is a reactant)

Writing a Formula Equation & Identify Symbols

What do the symbols tell you about the conditions of the two reactions shown below?

(1) $3H_{2\,(g)} + N_{2\,(g)} \xrightarrow{450^{o}} 2NH_{3\,(g)}$

(2) $2SO_2(g) + O_2(g) \xrightarrow{V_2O_5} 2SO_3(g)$

What do the symbols tell you about the conditions of the reaction shown below?

$$H_2CO_3(aq) \rightleftarrows CO_2(g) + H_2O(l)$$

Propane (C_3H_8) burns in oxygen to produce carbon dioxide and water. What are the reactants and products? Formulas?

Writing a Formula Equation & Identify Symbols

What do the symbols tell you about the conditions of the two reactions shown below?

(1) $3H_{2\,(g)} + N_{2\,(g)} \xrightarrow{450^o} 2NH_{3\,(g)}$

(2) $2SO_2(g) + O_2(g) \xrightarrow{V_2O_5} 2SO_3(g)$

The products and reactants of both reactions are gases.

Heat is used for reaction 1 while a catalyst is used for reaction 2.

What do the symbols tell you about the conditions of the reaction shown below?

$$H_2CO_3(aq) \rightleftarrows CO_2(g) + H_2O(l)$$

The reactant is dissolved in water.

A gas and a liquid are produced.

Reversible reaction (2 arrows).

Propane burns in oxygen to produce carbon dioxide and water. What are the reactants and products? Formulas?

The reactants are propane (C_3H_8) & oxygen (O_2). The products are CO_2 and H_2O.

Chemical Calculations

TRY IT

In a balanced chemical equation, the number of atoms of each element on the left equals the number of atoms of each element on the right.

Formation of Water			
Equation	$2Mg^{0}(s) + O_2^{0} \rightarrow 2Mg^{+2}O^{-2}(s)$		
Moles			
Molar Mass*			
Overall Mass R → P			

R (reactants) → P (products)

**Use the Periodic Table to find the information.*

Chemical Calculations

TRY IT

In a balanced chemical equation, the number of atoms of each element on the left equals the number of atoms of each element on the right.

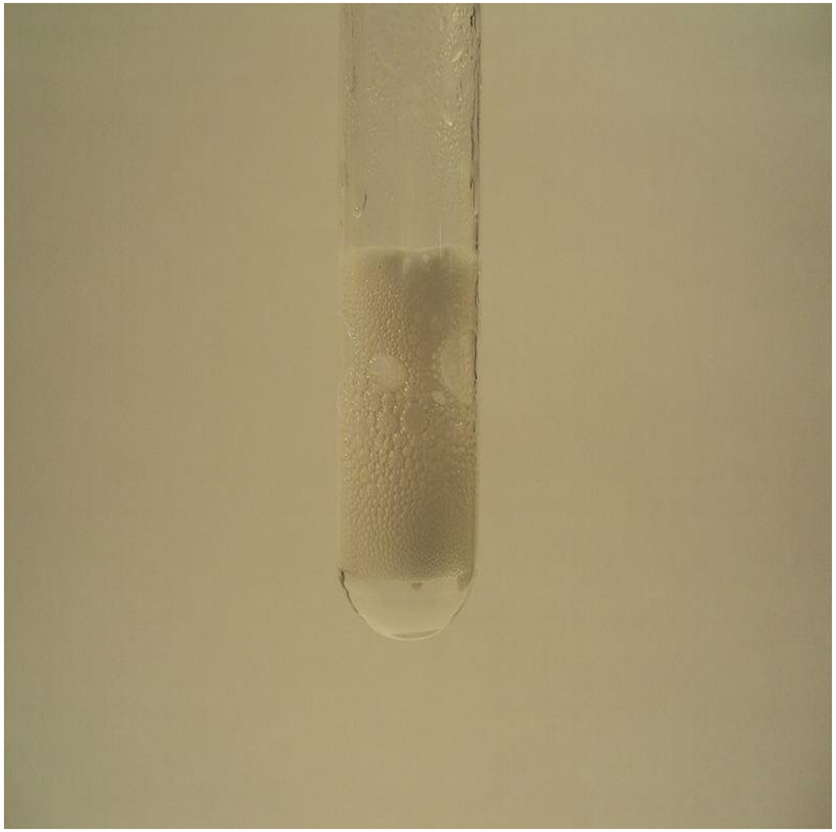
Formation of Water			
Equation	$2Mg^{0}(s) + O_2^{0} \rightarrow 2Mg^{+2}O^{-2}(s)$		
Amount coefficients	2 mol	1 mol	2 mol
Molar Mass	24 g	32 g	40 g
Mass (Moles × Molar Mass)	48 g	32 g	80 g

Notice the conservation of mass from reactants to products.

Effects on Reaction Rate

Magnesium reacts with hydrochloric acid to form hydrogen gas and magnesium chloride according to the following equation:

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$



Which of the following actions would *increase* the rate of reaction? Check all that apply:

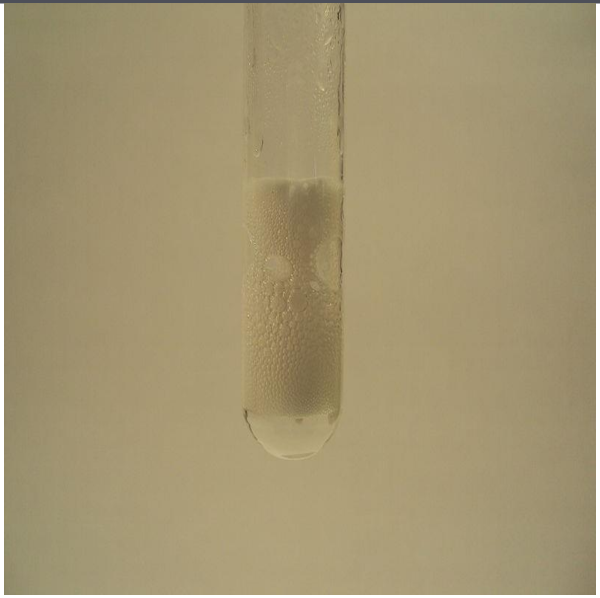
[ ] use hot hydrochloric acid solution

[ ] add water to the solution

[ ] use magnesium powder instead of a large piece of magnesium

[ ] increase the pressure on the system

Effects on Reaction Rate



Magnesium reacts with hydrochloric acid to form hydrogen gas and magnesium chloride according to the following equation:

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

Which of the following actions would *increase* the rate of reaction? Check all that apply:

[X] use hot hydrochloric acid solution … Increasing temperature > reaction rate

[ ] add water to the solution … Water is the solvent; therefore, less reactants (lower concentration)

[X] use magnesium powder instead of a large piece of magnesium … Increasing surface area > rxn rate

[ ] increase the pressure on the system More gas in the products favors the reverse rxn if Pressure is increased.

Explain Why Reaction Rates Change

Match the collision theory explanation to the strategy proposed to change the rate of a chemical reaction.

Collision Theory Explanations

A. Pressure
B. Concentration
C. Temperature
D. Surface Area

Strategies for changing reaction rates

____ Refrigerate food to keep it from spoiling

____ Adding extra ingredients to a reaction solution

____ Compressing the air/fuel mixture inside an engine cylinder with a piston

____ Using a pressure cooker to raise the boiling point of water

____ Grinding a metal into a fine powder.

Explain Why Reaction Rates Change

Match the collision theory explanation to the strategy proposed to change the rate of a chemical reaction.

Collision Theory Explanations

A. Pressure
B. Concentration
C. Temperature
D. Surface Area

Strategies for changing reaction rates

C	Refrigerate food to keep it from spoiling
B	Adding extra ingredients to a reaction solution
A	Compressing the air/fuel mixture inside an engine cylinder with a piston
A & C	Using a pressure cooker to raise the boiling point of water
D	Grinding a metal into a fine powder.

Predicting Equilibrium Shift due to Concentration

QUICK CHECK

$$SO_{2\,(g)} + NO_{2\,(g)} \rightleftharpoons SO_{3\,(g)} + NO_{(g)}$$

For the equilibrium system described by the equation above, what will happen if SO_3 is removed?

- The equilibrium shifts to the right (to replace product). Favors **forward** reaction.

For the equilibrium system described by the equation above, what will happen if SO_2 is removed?

– The equilibrium shifts to the left (to replace the reactant). Favors **reverse** reaction.

What will happen if NO is added?

– The equilibrium shifts to the left (to remove product). Favors **reverse** reaction.

What will happen if NO_2 is added?

– The equilibrium shifts to the right (to remove reactant). Favors **forward** reaction.

Stressing the system by Temperature causes a shift in equilibrium based on how heat flows.

Exothermic reaction

reactants → products + **heat**

- Adding heat causes shift to LEFT (*favors reverse reaction to relieve the stress of high energy products*)
- Removing heat causes shift to RIGHT

$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$

Brown Colorless

Stressing the system by Temperature causes a shift in equilibrium based on how heat flows.

Endothermic reaction

reactants + **heat** → products

- Adding heat causes shift to RIGHT (*favors forward reaction to relieve the stress of high energy reactants*)
- Removing heat causes shift to LEFT

$2NO_{2(g)} \rightleftharpoons N_2O_{4(g)}$

Brown Colorless

Predicting Equilibrium Shift due to Temperature

QUICK CHECK

$2POCl_{3\,(g)} + heat \rightleftharpoons 2PCl_{3\,(g)} + O_{2\,(g)}$

For the equilibrium system described by the equation above, what happens if temperature is decreased?

O equilibrium shifts right

O equilibrium shifts left

What happens if temperature is increased?

O equilibrium shifts right

O equilibrium shifts left

$2CO_{(g)} \rightleftharpoons CO_{2\,(g)} + C_{(s)} + heat$

For the equilibrium system described by the equation above, what happens if temperature is increased?

O equilibrium shifts right

O equilibrium shifts left

What happens if temperature is decreased?

O equilibrium shifts right

O equilibrium shifts left

Predicting Equilibrium Shift due to Temperature

QUICK CHECK

$$2POCl_{3\,(g)} + heat \rightleftharpoons 2PCl_{3\,(g)} + O_{2\,(g)}$$

For the equilibrium system described by the equation above, what happens if temperature is decreased?

Equilibrium shifts left to restore the heat that was lost. Favors **reverse** reaction.

What happens if temperature is increased?

Equilibrium shifts right to absorb the excess heat added. Favors **forward** reaction.

$$2CO_{(g)} \rightleftharpoons CO_{2\,(g)} + C_{(s)} + heat$$

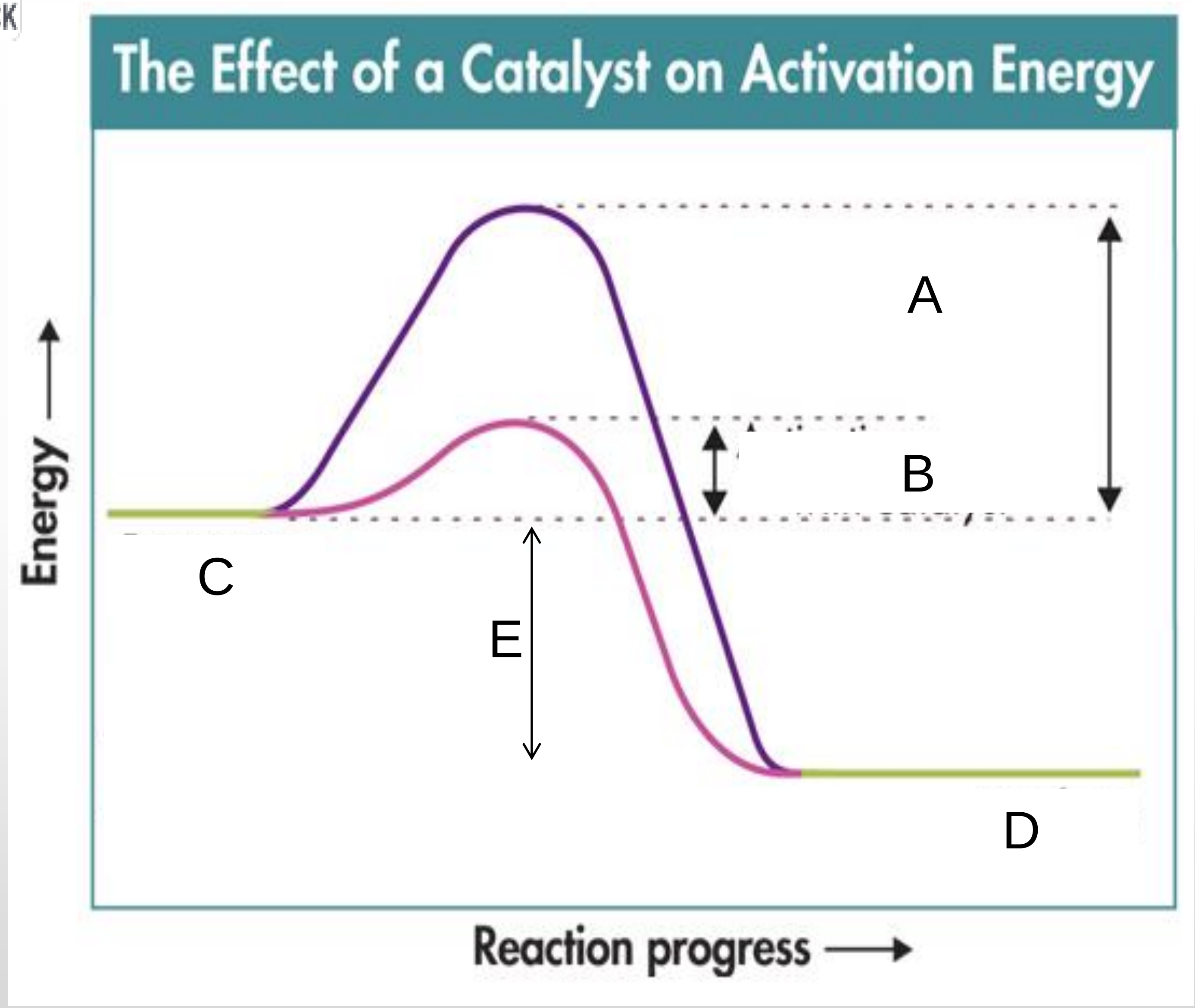
For the equilibrium system described by the equation above, what happens if temperature is increased?

Equilibrium shifts left to absorb the excess heat added. Favors **reverse** reaction.

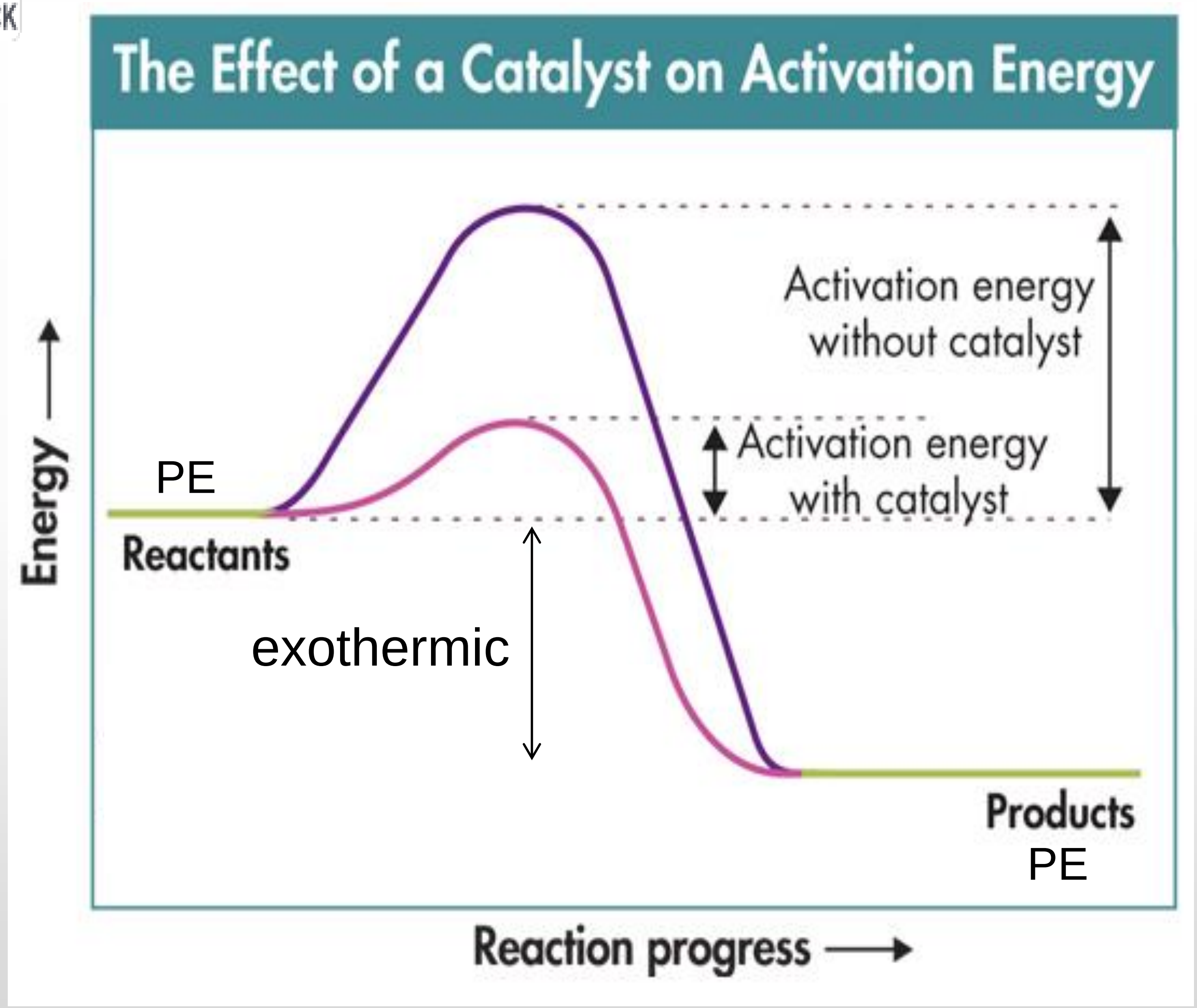
What happens if temperature is decreased?

Equilibrium shifts right to restore the heat that was lost. Favors **forward** reaction.

Label each letter on the PE diagram



PE diagram with Catalyst



QUICK CHECK

Factors Affecting Equilibrium: Le Châtelier's Principle

$$H_2CO_3(aq) \rightleftharpoons CO_2(aq) + H_2O(l)$$

How does decreasing the concentration of CO_2 affect this system?

How does increasing the concentration of CO_2 affect this system?

$$H_2CO_3(aq) \leftrightarrows CO_2(aq) + H_2O(l)$$

How does decreasing the concentration of H_2CO_3 affect this system?

How does increasing the concentration of H_2CO_3 affect this system?

QUICK CHECK

Factors Affecting Equilibrium: Le Châtelier's Principle

Add CO_2
Direction of shift ←

$$H_2CO_3(aq) \rightleftharpoons CO_2(aq) + H_2O(l)$$

Remove CO_2
Direction of shift →

Add H_2CO_3
Direction of shift →

$$H_2CO_3(aq) \rightleftharpoons CO_2(aq) + H_2O(l)$$

Remove H_2CO_3
Direction of shift ←

Factors Affecting Equilibrium: Le Châtelier's Principle

QUICK CHECK

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) + \text{heat}$$

How does adding heat affect this system?

How does removing heat affect this system?

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

How does increasing pressure affect this system?

How does decreasing pressure affect this system?

Factors Affecting Equilibrium: Le Châtelier's Principle

QUICK CHECK

Add heat

Direction of shift ←

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g) + \text{heat}$$

Remove heat (cool)

Direction of shift →

How does adding heat affect this system?

How does removing heat affect this system?

Add pressure

Direction of shift →

$$N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$$

Reduce pressure

Direction of shift ←

How does increasing pressure affect this system?

How does decreasing pressure affect this system?

QUICK CHECK

Applying Le Châtelier's Principle

What effect will each of the following changes have on the equilibrium position for this reversible reaction?

$$PCl_5(g) + \text{heat} \rightleftharpoons PCl_3(g) + Cl_2(g)$$

a. Cl_2 is added.

b. Pressure is increased.

c. Heat is removed.

d. PCl_3 is removed as it forms.

Applying Le Châtelier's Principle

What effect will each of the following changes have on the equilibrium position for this reversible reaction?

Add Cl_2

Direction of shift ←

$$PCl_5(g) + heat \rightleftharpoons PCl_3(g) + Cl_2(g)$$

Increase pressure

Direction of shift ←

$$PCl_5(g) + heat \rightleftharpoons PCl_3(g) + Cl_2(g)$$

Remove heat

Direction of shift ←

$$PCl_5(g) + heat \rightleftharpoons PCl_3(g) + Cl_2(g)$$

$$PCl_5(g) + heat \rightleftharpoons PCl_3(g) + Cl_2(g)$$

Remove PCl_3

Direction of shift →

KEY

Atomic Mass → 12.0111; Selected Oxidation States → −4, +2, +4; Symbol → **C**; Atomic Number → 6; Electron Configuration → $1s^2 2s^2 2p^2$

Relative atomic masses are based on ^{12}C = 12.00000

New Designation / Former Designation (prior to 1984 IUPAC decision)

s-block — GROUP 1, 2 (IA, IIA); *d*-block — Transition Elements — GROUP 3–10

Period	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8 VIII	9 VIII	10 VIII	
1	1.00794 **H** 1 $1s^1$ (+1, −1)										
2	6.941 **Li** 3 $1s^2 2s^1$ (+1)	9.01218 **Be** 4 $1s^2 2s^2$ (+2)									
3	22.98977 **Na** 11 $[Ne]3s^1$ (+1)	24.305 **Mg** 12 $[Ne]3s^2$ (+2)									
4	39.0983 **K** 19 $[Ar]4s^1$ (+1)	40.08 **Ca** 20 $[Ar]4s^2$ (+2)	44.9559 **Sc** 21 $[Ar]3d^1 4s^2$ (+3)	47.88 **Ti** 22 $[Ar]3d^2 4s^2$ (+2, +3, +4)	50.9415 **V** 23 $[Ar]3d^3 4s^2$ (+2, +3, +4, +5)	51.996 **Cr** 24 $[Ar]3d^5 4s^1$ (+2, +3, +6)	54.9380 **Mn** 25 $[Ar]3d^5 4s^2$ (+2, +3, +4, +7)	55.847 **Fe** 26 $[Ar]3d^6 4s^2$ (+2, +3)	58.9332 **Co** 27 $[Ar]3d^7 4s^2$ (+2, +3)	58.69 **Ni** 28 $[Ar]3d^8 4s^2$ (+2, +3)	63.546 29 [Ar]3d
5	85.4678 **Rb** 37 $[Kr]5s^1$ (+1)	87.62 **Sr** 38 $[Kr]5s^2$ (+2)	88.9059 **Y** 39 $[Kr]4d^1 5s^2$ (+3)	91.224 **Zr** 40 $[Kr]4d^2 5s^2$ (+4)	92.9064 **Nb** 41 $[Kr]4d^4 5s^1$ (+3, +5)	95.94 **Mo** 42 $[Kr]4d^5 5s^1$ (+3, +6)	(98) **Tc** 43 $[Kr]4d^6 5s^1$ (+4, +6, +7)	101.07 **Ru** 44 $[Kr]4d^7 5s^1$ (+3)	102.906 **Rh** 45 $[Kr]4d^8 5s^1$ (+3)	106.42 **Pd** 46 $[Kr]4d^{10} 5s^0$ (+2, +4)	107.868 47 [Kr]4d
6	132.905 **Cs** 55 $[Xe]6s^1$ (+1)	137.33 **Ba** 56 $[Xe]6s^2$ (+2)	**La-Lu** 57 71	178.49 **Hf** 72 $[Xe]4f^{14}5d^2 6s^2$ (+4)	180.948 **Ta** 73 $[Xe]4f^{14}5d^3 6s^2$ (+5)	183.85 **W** 74 $[Xe]4f^{14}5d^4 6s^2$ (+6)	186.207 **Re** 75 $[Xe]4f^{14}5d^5 6s^2$ (+4, +6, +7)	190.2 **Os** 76 $[Xe]4f^{14}5d^6 6s^2$ (+3, +4)	192.22 **Ir** 77 $[Xe]4f^{14}5d^7 6s^2$ (+3, +4)	195.08 **Pt** 78 $[Xe]4f^{14}5d^9 6s^1$ (+2, +4)	196.96 79 [Xe]4f
7	(223) **Fr** 87 $[Rn]7s^1$ (+1)	226.025 **Ra** 88 $[Rn]7s^2$ (+2)	**Ac-Lr** 89 103	(261) **Unq*** 104	(262) **Unp** 105	(263) **Unh** 106	(262) **Uns** 107	**Uno** 108	**Une** 109		

* The sys
103 wil

nasses are
2.00000

lation States

s-block

	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 O
									4.00260 0 **He** 2 $1s^2$
				10.81 +3 **B** 5 $1s^22s^22p^1$	12.0111 −4 +2 +4 **C** 6 $1s^22s^22p^2$	14.0067 −3 −2 −1 +1 +2 +3 +4 +5 **N** 7 $1s^22s^22p^3$	15.9994 −2 **O** 8 $1s^22s^22p^4$	18.998403 −1 **F** 9 $1s^22s^22p^5$	20.179 0 **Ne** 10 $1s^22s^22p^6$
				26.98154 +3 **Al** 13 $[Ne]3s^23p^1$	28.0855 −4 +2 +4 **Si** 14 $[Ne]3s^23p^2$	30.97376 −3 +3 +5 **P** 15 $[Ne]3s^23p^3$	32.06 −2 +4 +6 **S** 16 $[Ne]3s^23p^4$	35.453 −1 +1 +3 +5 +7 **Cl** 17 $[Ne]3s^23p^5$	39.948 0 **Ar** 18 $[Ne]3s^23p^6$
	58.69 +2 +3 **Ni** 28 $[Ar]3d^84s^2$	63.546 +1 +2 **Cu** 29 $[Ar]3d^{10}4s^1$	65.39 +2 **Zn** 30 $[Ar]3d^{10}4s^2$	69.72 +3 **Ga** 31 $[Ar]3d^{10}4s^24p^1$	72.59 −4 +2 +4 **Ge** 32 $[Ar]3d^{10}4s^24p^2$	74.9216 −3 +3 +5 **As** 33 $[Ar]3d^{10}4s^24p^3$	78.96 −2 +4 +6 **Se** 34 $[Ar]3d^{10}4s^24p^4$	79.904 −1 +1 +5 **Br** 35 $[Ar]3d^{10}4s^24p^5$	83.80 0 +2 **Kr** 36 $[Ar]3d^{10}4s^24p^6$
	106.42 +2 +4 **Pd** 46 $[Kr]4d^{10}5s^0$	107.868 +1 **Ag** 47 $[Kr]4d^{10}5s^1$	112.41 +2 **Cd** 48 $[Kr]4d^{10}5s^2$	114.82 +3 **In** 49 $[Kr]4d^{10}5s^25p^1$	118.71 +2 +4 **Sn** 50 $[Kr]4d^{10}5s^25p^2$	121.75 −3 +3 +5 **Sb** 51 $[Kr]4d^{10}5s^25p^3$	127.60 −2 +4 +6 **Te** 52 $[Kr]4d^{10}5s^25p^4$	126.905 −1 +1 +5 +7 **I** 53 $[Kr]4d^{10}5s^25p^5$	131.29 0 +2 +4 +6 **Xe** 54 $[Kr]4d^{10}5s^25p^6$
	195.08 +2 +4 **Pt** 78 $[Xe]4f^{14}5d^96s^1$	196.967 +1 +3 **Au** 79 $[Xe]4f^{14}5d^{10}6s^1$	200.59 +1 +2 **Hg** 80 $[Xe]4f^{14}5d^{10}6s^2$	204.383 +1 +3 **Tl** 81 $[Xe]4f^{14}5d^{10}6s^26p^1$	207.2 +2 +4 **Pb** 82 $[Xe]4f^{14}5d^{10}6s^26p^2$	208.980 +3 +5 **Bi** 83 $[Xe]4f^{14}5d^{10}6s^26p^3$	(209) +2 +4 **Po** 84 $[Xe]4f^{14}5d^{10}6s^26p^4$	(210) **At** 85 $[Xe]4f^{14}5d^{10}6s^26p^5$	(222) 0 **Rn** 86 $[Xe]4f^{14}5d^{10}6s^26p^6$

p-block: GROUP 13–18