WELCOME TO PERIOD 12: CONSEQUENCES OF USING CHEMICAL ENERGY

Homework #11 is due today.

Midterm 1 grade curve:
A 29-33: 17% (of 166 students)
B 25-28: 34%
C 20-24: 32%
D 15-19: 14%
E 0-14: 3%  Average score = 24.1
• How does combustion of fossil fuels affect the Earth’s environment?
• What are the consequences of fossil fuel use for human health?
<table>
<thead>
<tr>
<th>Physical change: no change in chemical composition</th>
<th>Chemical change: new compounds are formed</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ No change to the compounds or substances.</td>
<td>✓ One or more substances are partially used up.</td>
</tr>
<tr>
<td>✓ Energy may be absorbed or released.</td>
<td>✓ One or more new substances are formed.</td>
</tr>
<tr>
<td>✓ Example: a phase change between solid and liquid phases or between liquid and gas phases</td>
<td>✓ Energy may be absorbed or released.</td>
</tr>
<tr>
<td></td>
<td>✓ Some compounds are partially used up and new compounds are formed.</td>
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</tbody>
</table>
Exothermic reactions give off energy.

Chemical energy is converted into another form of energy, such as thermal, radiant, or electrical energy.

Examples: combustion, batteries

Endothermic reactions must have energy put in to occur.

Some form of energy, such as thermal, radiant, or electrical energy, is converted into chemical energy.

Examples: photosynthesis, recharging batteries, electroplating
Electrostatic precipitator removes soot

- High voltage wires inside the precipitator ionize particles in the air, giving them an electric charge.

- The charged particles are attracted to a plate or wire with the opposite charge.

- The solid particles are removed from the air before it leaves the chimney.

Source: wikipedia.org/wiki/Electrostatic_precipitator
Complete and incomplete combustion

When carbon combines with sufficient oxygen, carbon dioxide and heat energy result.

**Complete combustion:** \( C + O_2 \rightarrow CO_2 + \text{energy (heat)} \)

When carbon combines with insufficient oxygen, carbon monoxide and heat result.

**Incomplete combustion:** \( 2C + O_2 \rightarrow 2CO + \text{energy} \)

Both carbon dioxide and carbon monoxide are undesirable.

- Carbon dioxide is a greenhouse gas that contributes to climate change. (To be discussed in period 14.)
- Carbon monoxide is a toxic gas that can be fatal if inhaled.
Carbon monoxide (CO)

- Carbon monoxide molecules in the blood take away oxygen from the hemoglobin molecules. This lowers the oxygen-carrying ability of the blood.

- Carbon monoxide poisoning can result in oxygen starvation and death.

- CO can be produced by any source of incomplete combustion, such as gas or oil furnaces, water heaters, kerosene space heaters, or fireplaces.

- CO from the exhaust of car motors running in an attached garage can seep into a home and be fatal.

Never run an automobile in a closed garage!

- Symptoms of CO poisoning include headaches, nausea, and fatigue. At higher concentrations: drowsiness, confusion, convulsions, unconsciousness, and death.
Causes of acid rain

- Oxides of sulfur ($S_2\text{O}_2$ and $S_2\text{O}_3$) emitted when high sulfur coal is burned combine with water molecules in the atmosphere to form sulfuric acid molecules.

- Oxides of nitrogen ($NO$, $NO_2$, $N0_3$) emitted from gasoline and diesel engines combine with water to form nitric acid molecules.

- When these molecules precipitate, the result is weakly acidic rain.
Effects of acid rain

- In the atmosphere, these oxides are harmful to human health.
- As acid rain, sulfur and nitric acid damage trees and other plants.
- Acid rain increases the acidity of lakes and streams, harming aquatic organisms.
- Buildings and statues are damaged by acid rain.
Photochemical smog

- Heat and pressure in gasoline and diesel engines produce oxides of nitrogen: $\text{NO, NO}_2, \text{NO}_3$

- Oxides of nitrogen and hydrocarbons can interact with oxygen to form smog.

- These pollutants react photochemically when exposed to ultraviolet radiant energy from the Sun.

Smog over New York City
Source: wikipedia.org/wiki/File:SmogNY.jpg
Reducing photochemical smog

✓ **Catalysts** change the rates of chemical reactions by reducing the amount of activation energy required.

✓ Oxides of nitrogen decompose slowly into $\text{N}_2$ and $\text{O}_2$.

✓ Automobile **catalytic converters speed up this decomposition**.

Catalysts do not change the outcome of the reaction.

The catalyst is not used up in the reaction.
Atmospheric inversions

- Inversions occur when a layer of warm air lies above cooler air.
- Since warm air rises and cool air sinks, there is no mixing of the layers of air.
- The temperature inversion traps pollution near the Earth’s surface.
Earth’s ozone layer

✓ Atmospheric ozone forms a layer in the stratosphere, 20 km to 30 km above the Earth’s surface.

✓ Ozone forms when ultraviolet light splits oxygen molecules into two oxygen atoms: \( \text{O}_2 + \text{UV} \rightarrow \text{O} + \text{O} \)

✓ These oxygen atoms combine with \( \text{O}_2 \) molecules to form ozone. \( \text{O}_2 + \text{O} \rightarrow \text{O}_3 \)

✓ Ozone molecules can absorb ultraviolet light, reducing the amount of UV radiation that penetrates the Earth’s atmosphere. \( \text{O}_3 + \text{UV} \rightarrow \text{O}_2 + \text{O} \)

✓ UV radiation can cause skin cancer.

✓ Nitrogen oxides from aircraft engines and CFCs (chlorinated fluorocarbons) from freon and aerosol cans combine with ozone to deplete the protective ozone layer.
1. Oxygen molecules are photolyzed, yielding 2 oxygen atoms (SLOW)

2. Ozone and oxygen atoms are continuously being interconverted as solar UV breaks ozone and the oxygen atom reacts with another oxygen molecule (FAST)

3. Ozone is lost by a reaction of the oxygen atom or the ozone molecule with each other, or some other trace gas such as chlorine (SLOW)

This interconversion process converts UV radiation into thermal energy, heating the stratosphere

Source: wikipedia.org/wiki/Ozone_layer
Thermal pollution

- Heat engines cannot convert all of their thermal energy into mechanical energy. Some of the thermal energy is released as waste heat.

- In electric power plants, large amounts of thermal energy must be removed from the steam used to turn the turbines.

- The waste heat is released into lakes or rivers.

- This hot water causes changes in the wildlife and may lead to the elimination of some species.

- Of the energy presently used in the United States, about 10% is rejected from electric power plants in the form of waste thermal energy.
River water is pumped into the boiler, heated to steam, and returned to the river at a higher temperature.
BEFORE THE NEXT CLASS…

✓ Read textbook chapter 13.
✓ Complete Homework Exercise 12.
✓ Print out Activity Sheet 13.