## Heat and temperature changes

## Temperature changes compared to heat energy added

- Remember *this assumes NO chemical changes occur*
- the more heat added the more temperature change.
- *Unless we are at a phase change point!!
- The more matter present the less the temperature will change.
- The type of matter present also has an effect on the temperature change.

## Heat capacity

- ~the rate of temperature change compared to the amount of heat energy added (or removed) with no chemical change for a specific substance.
- Every substance absorbs heat differently.
- Applying the same amount of heat to equal amounts of iron and water their rate of temperature change will differ.
- (The pan gets hotter much faster than the water)

## Molar heat capacity

- We will mainly use molar heat capacity, which is the rate of temperature change per mole.
- It's symbol is C
- It is measured in J/(K mol)
- These will normally be givens in the problem.

## Specific Heat Capacity

- Same idea as molar heat capacity, but it is measured per gram as opposed to per mole.
- It is necessary if you don't know what the metal is you are working with.
- Its symbol is c (its is written as "s" in your book, for the AP test it is c).
- It is measured in J /(K g)

## Table of molar heat capacities

| Substance | C | Substance | C |
|---|---|---|---|
| Water (Liquid) | 75.3 J / K mol | Helium | 25.2 J / K mol |
| Water (Gas) | 36.8 J / K mol | Hydrogen | 28.8 J / K mol |
| Water (Solid) | 38.09 J / K mol | Nitrogen | 29.1 J / K mol |
| Lead (Solid) | 26.7 J / K mol | Aluminum | 24.2 J / K mol |
| Lead (Liquid) | 27.4 J / K mol | Tungsten | 24.2 J / K mol |
| Iron | 25.1 J / K mol | Octane | 254 J / K mol |
| Silver | 25.3 J / K mol | NaCl | 50.5 J / K mol |
| Cobalt | 50.6 J / K mol | Nickel | 26.1 J / K mol |
| Silicon | 19.7 J / K mol | Zinc | 25.2 J / K mol |
| Cadmium | 25.6 J / K mol | Gold | 25.42 J / K mol |

## Table of specific heat capacities

| Substance | c | Substance | c |
|---|---|---|---|
| Water (Liquid) | 4.183 J/K g | Helium | 5.193 J/K g |
| Water (Gas) | 2.080 J/K g | Hydrogen | 14.30 J/K g |
| Water (Solid) | 2.05 J/K g | Nitrogen | 1.04 J/K g |
| Lead (Solid) | 0.129 J/K g | Aluminum | 0.891 J/K g |
| Lead (Liquid) | 0.132 J/K g | Tungsten | .132 J/K g |
| Iron | 0.449 J/K g | Octane | 2.22 J/K g |
| Silver | 0.233 J/K g | NaCl | .864 J/K g |
| Cobalt | 0.858 J/K g | Nickel | 0.444 J/K g |
| Silicon | 0.701 J/K g | Zinc | 0.388 J/K g |
| Cadmium | 0.228 J/K g | Gold | .129 J/K g |

## Throwing it all into one equation

- The symbol for heat energy is q (J)
- Molar heat capacity is C (J/mol K)
- Temperature is T, change in temperature is $\Delta T$ (K)
- $\Delta T$ is calculated by final temp-initial temp ($T_f$-$T_i$)
- The symbol for number of particles is n (mol)

- **$q = n C \Delta T$**
- **$q = n C (T_f - T_i)$**

## ------Or------

- The symbol for heat energy is q (J)
- specific heat capacity is c (J/ g K)
- Temperature is T, change in temperature is $\Delta T$ (K)
- $\Delta T$ is calculated by final temp-initial temp ($T_f$-$T_i$)
- The symbol for mass m (g)

- **$q = m c \Delta T$**
- **$q = m c (T_f - T_i)$**

## Using this equation

- If 3940 J of energy is added to 43.9 mol of tungsten at 265 K, what will the final temperature be?
- $q = n C \Delta T$

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- If 3940 J of energy is added to 43.9 mol of tungsten at 265 K, what will the final temperature be?
- $q = n C \Delta T$
- 3940 J = 43.9 mol (24.2 J/K mol) ($T_f$ – 265 K)
- $T_f$ = 269 K
- *Always make sure all units agree, I will include several conversions in these problems.

## And the other…

- 14.2 g of an unknown metal is heated with 998 J of energy. The temperature rises from 287.2 K to 366.1K, what is the metal?
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- 14.2 g of an unknown metal is heated with 998 J of energy. The temperature rises from 287.2 K to 366.1K, what is the metal?
- $q = m c \Delta T$
- 998 J = 14.2 g c (366.1-287.2)
- c = .891 J/ g K
- It is closest to aluminum on our list.

## Just warming up

- 259 mol of sodium chloride is heated from 35$^o$ C to 68$^o$ C, how much heat was added?
- $q = n C \Delta T$

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- 259 mol of sodium chloride is heated from 35$^o$ C to 68$^o$ C, how much heat was added?
- $q = n C \Delta T$
- 259mol (50.5J/molK)(341K – 308K) = q
- 259mol (50.5J/molK)(33K) = q
- q = 430,000 J or 430 kJ

## Last one

- If 3.87 kJ of heat is added to silver at 21$^o$C and it heats to 74$^o$C, how many moles were present?

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- If 3.87 kJ of heat is added to silver at 21$^o$C and it heats to 74$^o$C, how many moles were present?
- $q = n c \Delta T$
- 3870 J = n 25.3 J/mol K (53 K)
- n = 2.9 mol