Problem Set #12 Heat Transfer and Climate Change Connections
Due Thursday March 12

Name: Key

I worked with:

Equations:

Force:	F = ma
Force due to Gravity on Earth:	F = mg
Acceleration due to gravity on Earth:	g = 9.8 m/s^2
Work	W = F*d

Thermodynamics

First Law	$\Delta U = Q - W$
Heat	$q = mC_p\Delta T$
Temperature Change	$\Delta T = T_{final} - T_{initial}$

Waves

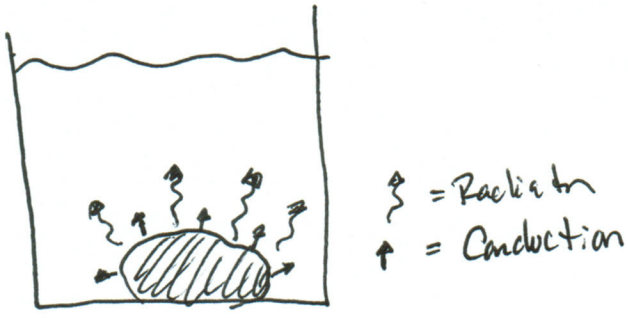
Simplified Wave Equation	$x = Asin(\omega t)$
Angular Velocity to Frequency	$\omega = 2\pi f$
Speed of a Light Wave	$c = \lambda f$
Speed of light in a vacuum	$c = 3 \times 10^8 m/s$
Energy of Light per photon	$E = hf$
Planck's Constant	$h = 6.626 \times 10^{-34} Js$

1. A 10 kg stone that has a temperature of 100 °C is put into a 60 L tub of water that has a temperature of 25 °C. The water warms up until it is at a temperature of 27.87 °C.

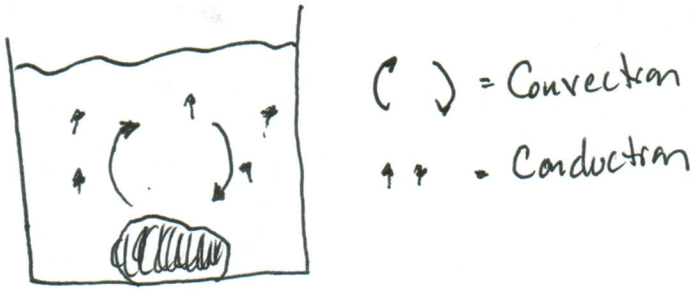
Helpful information:

1 L = 0.001 m^3
Density of water: ρ = 997 kg/m^3
Specific heat of water: C_p = 4,200 J/kg°C
Specific heat of Stone: C_p = 1000 J/kg°C

a. Use words and pictures to describe how the Thermal energy of the stone is transferred to the water. (Be sure to include either Conduction, Convection, or Radiation)



b. Use words and pictures to describe how the Thermal energy is moved within the water. (Be sure to include either Conduction, Convection, or Radiation)



c. How much heat was transferred from the stone to the water?

$q = mc_p\Delta T = mc_p(T_f - T_i)$

mass of water $\Rightarrow$ Volume $= 60 \times 0.001 = 0.06$

$60L \times 0.001 \frac{m^3}{L}$

mass = volume x density $= 0.06 \times 997 = 59.82\ kg$

$q = 59.82 \times 4200 \times (27.87 - 25) = 721,070.J$

d. How much heat did the stone lose?

$-721,070\ J$

e. (Honors) What is the final temperature of the stone? Will the stone continue to lose any more Thermal Energy? Why or why not?

$q = m c_p \Delta T$

$-721,070 = 10 \times 1000 \times (T_f - 100)$

$\frac{-721,070}{10,000} = T_f - 100$

$-72.1 = T_f - 100$

$+100 \quad +100$

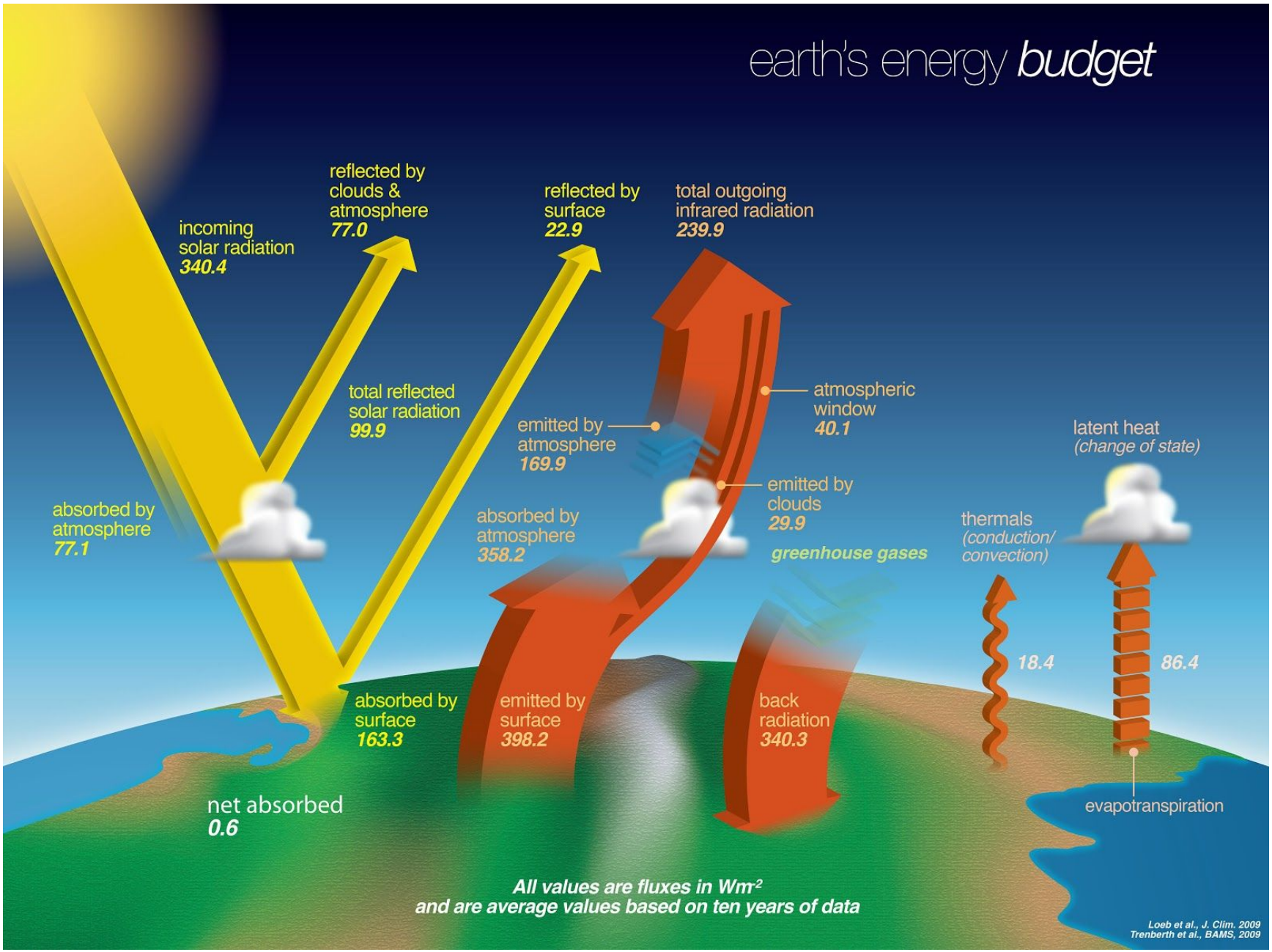
$T_f = 27.89\,^{\circ}C$

The stone and water are in Thermal equilibrium and the stone will not lose any more heat because they are at the same temperature

2. Using words and pictures explain the feedback cycle that is causing arctic amplification and how this impacts the rest of the earth.

see attached Earth's Engy Budget + for Picture

when visible light from the sun hits ice a lot of that energy is reflected. However if the ice is not there, the water absorbs the visible light and eventually radiates Infrared light back out into the atmosphere. Carbon Molecules in the atmosphere absorb IR light very well (where visible light would have passed through) and trapped in our atmosphere. which heats up and radiates IR light back, causing a feedback loop that heats the Arctic and impacts the rest of the planets


earth's energy budget
incoming solar radiation 340.4
reflected by clouds & atmosphere 77.0
reflected by surface 22.9
total outgoing infrared radiation 239.9
total reflected solar radiation 99.9
atmospheric window 40.1
emitted by atmosphere 169.9
emitted by clouds 29.9
greenhouse gases
absorbed by atmosphere 77.1
absorbed by atmosphere 358.2
latent heat (change of state)
thermals (conduction/ convection)
18.4
86.4
absorbed by surface 163.3
emitted by surface 398.2
back radiation 340.3
net absorbed 0.6
evapotranspiration
All values are fluxes in Wm-2
and are average values based on ten years of data
Loeb et al., J. Clim. 2009
Trenberth et al., BAMS, 2009