Heat and Temperature

Heat or Temperature

- A cold, wet, wintry camp
- A “bonfire” or an “everlasting match”?
- Higher Temperature?
- More Heat

Temperature Units

- Degrees Fahrenheit
- Degrees Celsius
- Kelvin

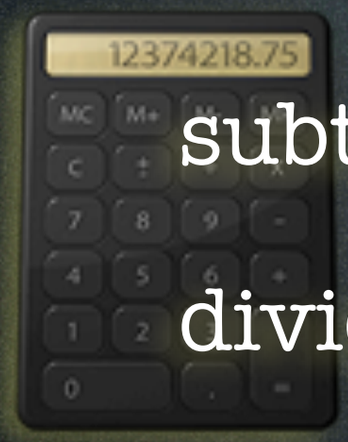
Temperatures You Should Know

- Water Freezes...
- Water Boils....
- Absolute Zero

Temperature Conversions

- °F to °C
- Water Boils at 212 °F
  - subtract 32
  - divide by 180/100
    - 9/5 or 1.8
- 100 °C

Temperature Checks

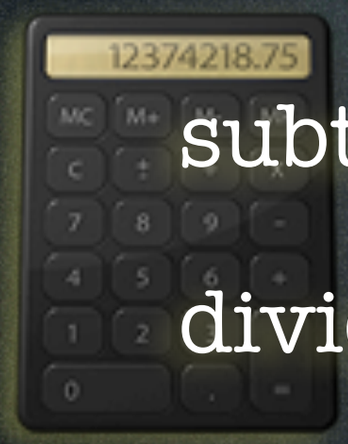


subtract 32

divide by 9/5 or 1.8

- **Warm Summer Day**
- **86 °F**
- **30 °C**

Temperature Checks

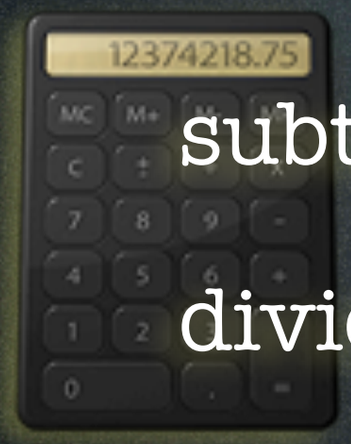


subtract 32

divide by 9/5 or 1.8

- **Cold Winter Day**
- **14 °F**
- **-10 °C**

Temperature Checks



subtract 32

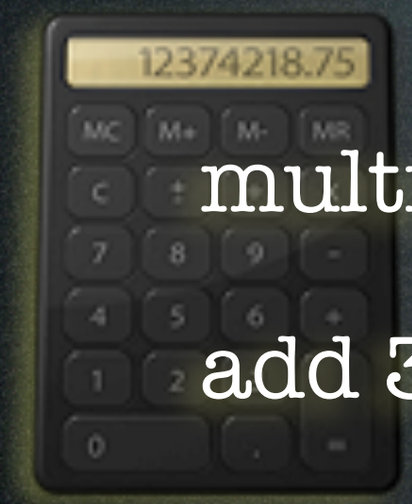
divide by 9/5 or 1.8

- **Body Temperature**
- **98.6 °F**
- **37 °C**

Temperature Conversions

- °C to ^{0}F
  - Water Boils at 100 °C
  - multiply by 180/100
    - 9/5 or 1.8
  - add 32
  - 212 ^{0}F

Temperature Checks



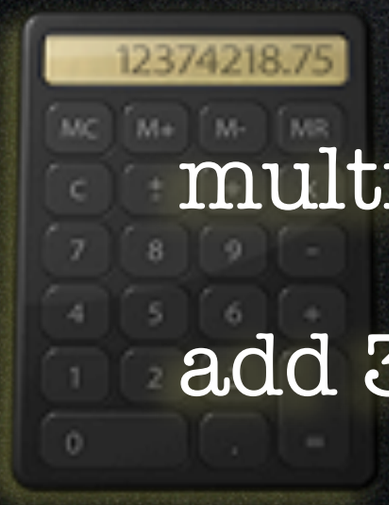
multiply by 9/5 or 1.8

add 32

- **Nice spring day**
- **20 °C**
- **68 °F**

Temperature Checks

- **Trick Question?**
- **-40 °C**
- **-40 °F**



multiply by 9/5 or 1.8

add 32

Kelvin

- Absolute Zero
- Celsius plus 273
- temperature as a measure of kinetic energy

Heat

- “How many donuts do you have? ”
- “How many donuts are you selling? ”
- Quantity of thermal energy transfered

Heat Units

- **calorie**
  - the amount of energy required to raise the temperature of one **gram** of water by 1 °C
- **Calorie**
  - the amount of energy required to raise the temperature of one **kilogram** of water by 1 °C
- **Joule**
  - 4.186 J = 1 calorie

Heat Units

- B.T.U. - British Thermal Unit
  - the amount of heat required to raise the temperature of one pound of liquid water by one degree from 60° to 61°Fahrenheit at a constant pressure of one atmosphere

Diet Advice

- Drink Water!

Calories	Calories from fat	Total Fat (g)	Saturated Fat (g)	Trans Fat (g)	Cholesterol (mg)	Sodium (mg)	Total Carbs (g)	Dietary Fiber (g)	Sugars (g)	Protein (g)
270	140	15	7	0	0	340	31	1	13	
		23%	35%		0%	14%	10%	4%		

Calories	Calories from fat	Total Fat (g)	Saturated Fat (g)	Trans Fat (g)	Cholesterol (mg)
290	130	14	7	0	0	340

Diet Advice

- Drink Water?
- Two donuts = 560 Calories
- Cold Water Temp?
- 2 °C ?
- Body Temp?
- 37 °C
- 35 Calories for every liter of water
- 560/35 = 16 liters

Specific Heat

- How to deal with the hot sand at noon
- How to deal with the cold sand at night

Specific Heat

$$Q = mc\Delta T$$

- Q - Heat
- m- mass
- ΔT - Change in Temperature
- c - specific heat

Specific Heat Capacities

cal / g °C

Heat of fusion : water

80 cal/g

334.5 kJ/kg

Heat of vaporization : water

2260 kJ/kg

540 cal/g

Substance	J/kg °C	cal/g °C
Ice	2093	0.500
Water	4186	1.000
Steam	2009	0.480
Wood (typical)	1674	0.400
Methyl Alcohol	2549	0.609
Soil (typical)	1046	0.250
Air (50 °C)	1046	0.250
Aluminum	900	0.215
Glass (typical)	837	0.200
Iron/Steel	452	0.108
Copper	387	0.0924
Silver	236	0.0564
Mercury	138	0.0330
Gold	130	0.0310
Lead	128	0.0305

Two Water Samples

200 ml
100°

200 ml
20°

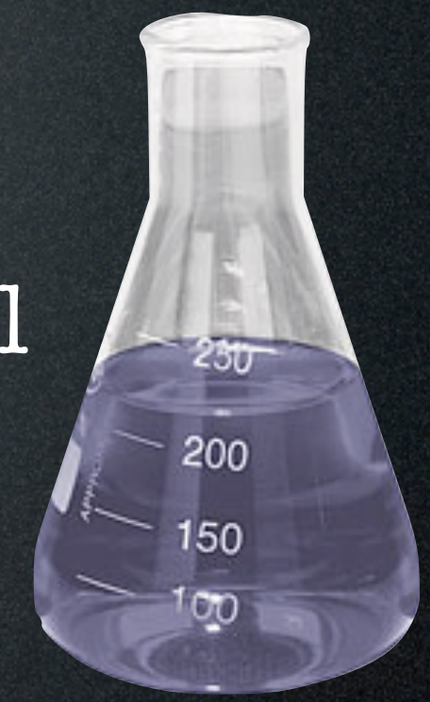
Multiple Choice - Style

A	B	C	D	E
100	80	60	40	20

Two Water Samples

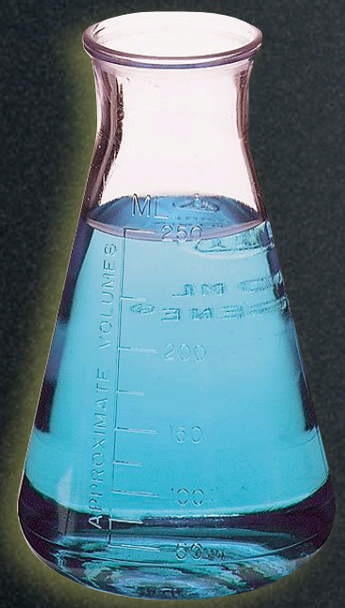
200 ml
100°

200 ml
20°



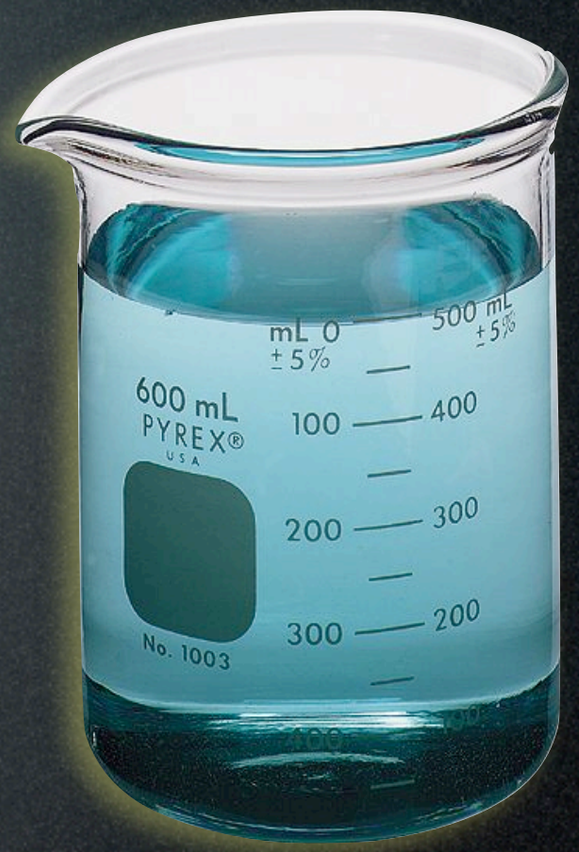
m	c	ΔT		m	c	ΔT
200	1	100-Tf	=	200	1	Tf - 20

Two Water Samples



200 ml
100°

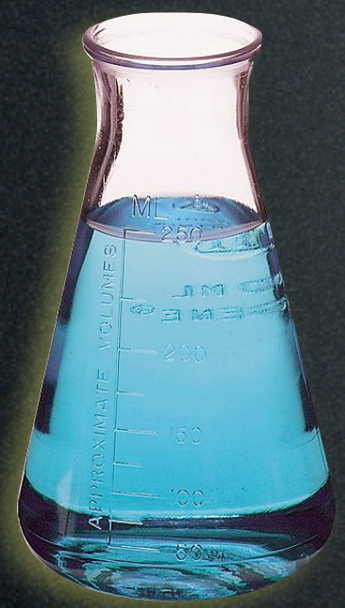
500 ml
20°



Multiple Choice - Style

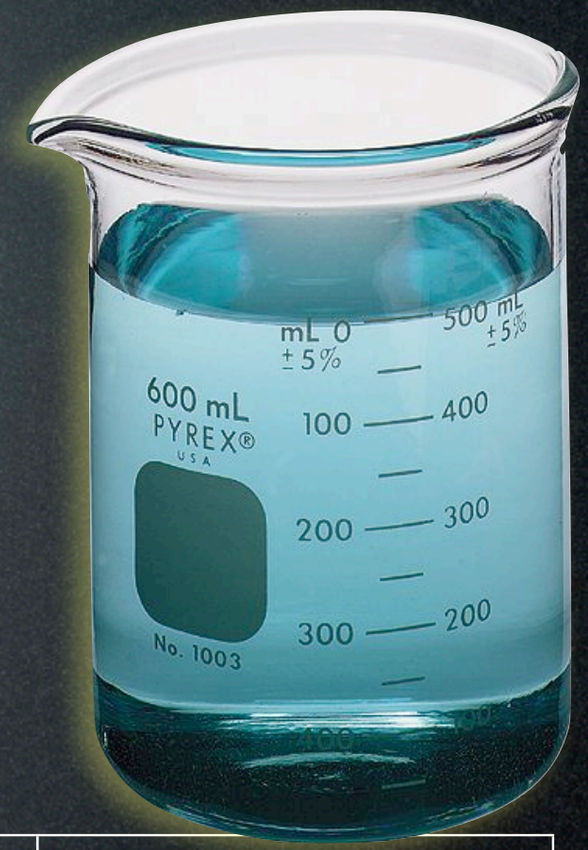
A	B	C	D	E
100	80	60	40	20

Two Water Samples



200 ml
100°

500 ml
20°



m	c	ΔT		m	c	ΔT
200	1	$100-T_f$	=	500	1	$T_f - 20$

Basic Calorimetry

250 g
Copper
100°

500 ml
Water
20°

Multiple Choice - Style

A	B	C	D	E
100	95	60	25	20

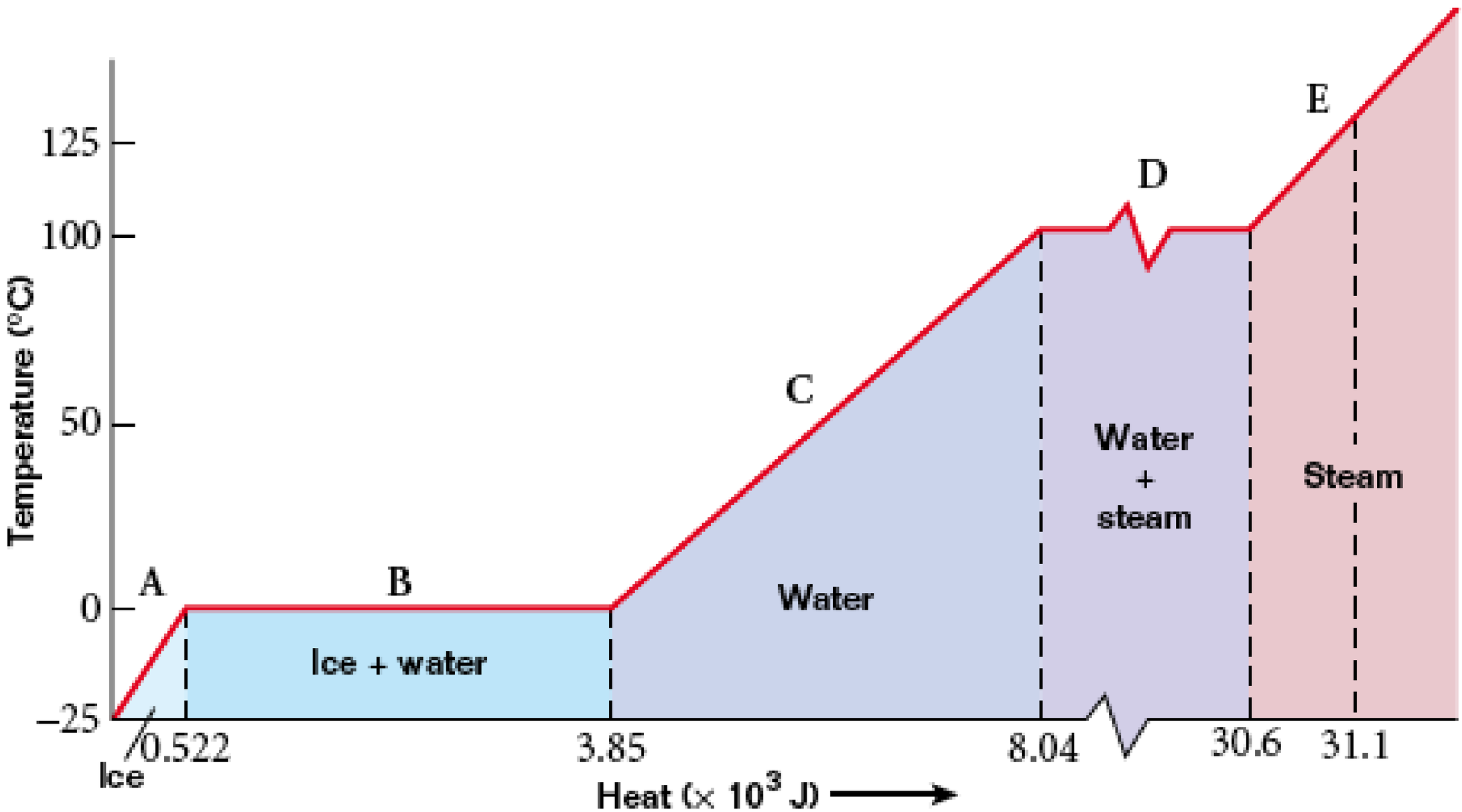
Basic Calorimetry

250 g
Copper
100°

500 ml
Water
20°

m	c	ΔT		m	c	ΔT
250	0.09	$100-T_f$	=	500	1	$T_f - 20$

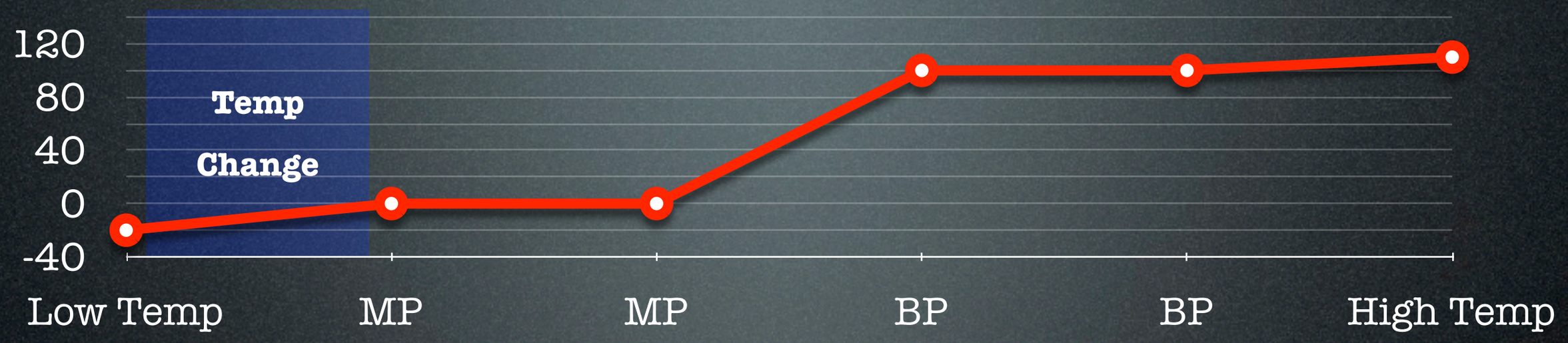
Temperatures with Phase Changes



Energy through Phase Changes

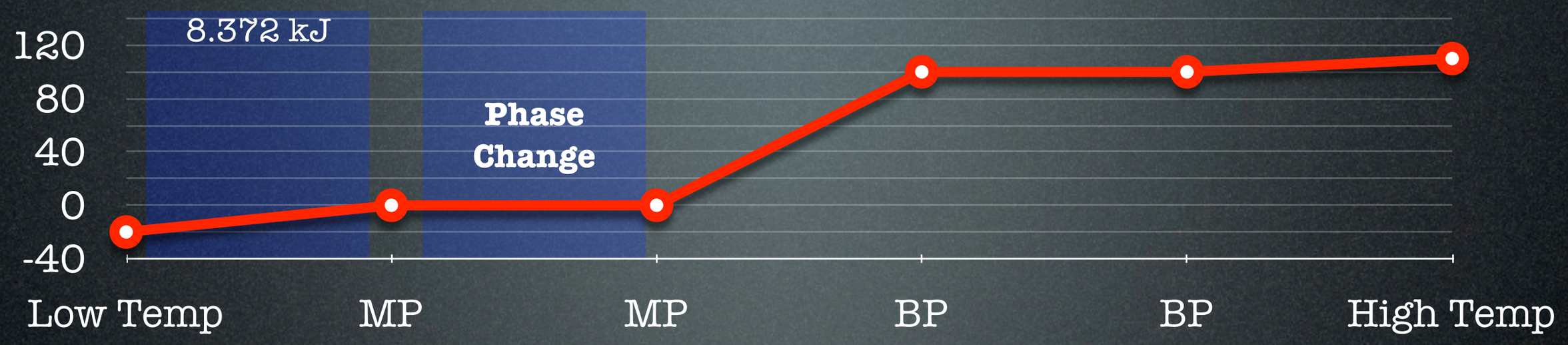
- How much thermal energy is required to change the temperature of 200 g of H_2O from -20^{0}C to 110^{0}C?

5 Step Solution



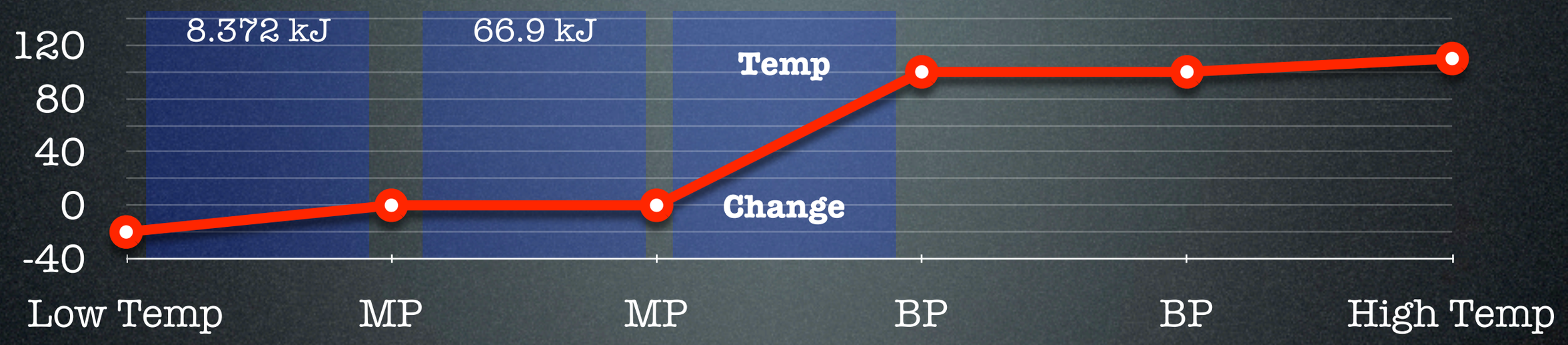
- **1) Warming the Ice**
  - $Q = mc\Delta T$
  - $Q = (200g)(2.093\ {}^{J}/_{g\,C})(20)$
  - $Q = 8{,}372\ J$
  - $Q = 8.372\ kJ$

5 Step Solution



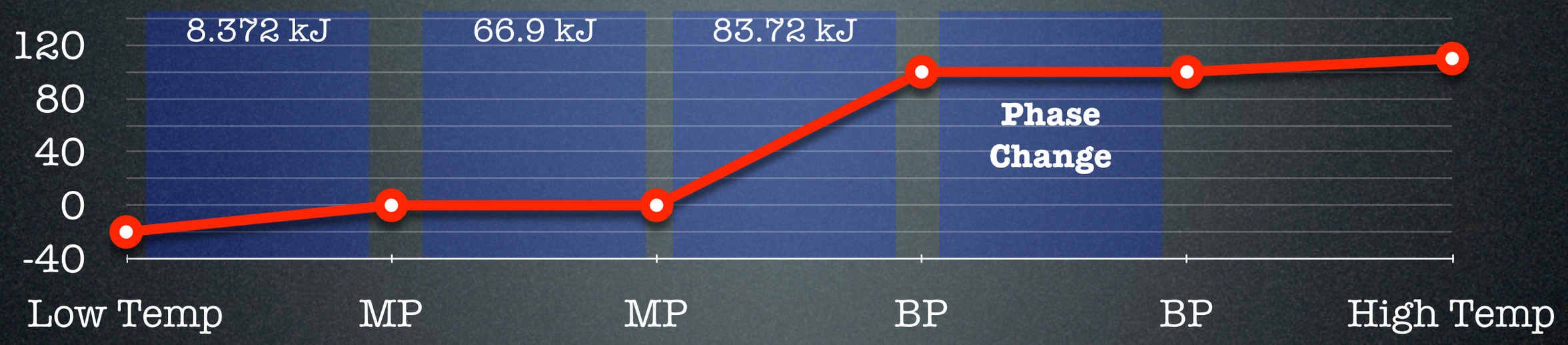
- **2) Melting the Ice**
  - $Q = mL_f$
  - $Q = (200g)(334.5\ ^{J}/_{g})$
  - $Q = 66{,}900\ J$
  - $Q = 66.9\ kJ$

5 Step Solution



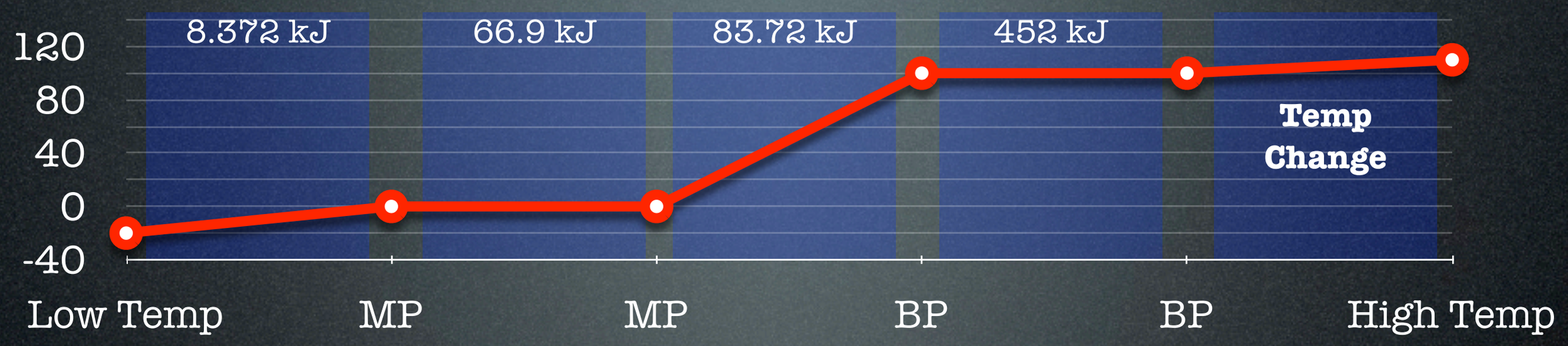
- **3) Warming the water**
  - $Q = mc\Delta T$
  - $Q = (200g)(4.186\ {}^{J}/_{g\,C})(100\ C^{o})$
  - $Q = 83{,}720\ J$
  - $Q = 83.720\ kJ$

5 Step Solution



- **4) Boiling (Evaporating) the water**
  - $Q = mL_v$
  - $Q = (200g)(2260\ ^{J}/_{g})$
  - $Q = 452{,}000\ J$
  - $Q = 452\ kJ$

5 Step Solution



- **5) Heating the Steam**
  - $Q = mc\Delta T$
  - $Q = (200g)(2.009\ {}^{J}/_{g\,C})(10)$
  - $Q = 4{,}018\ J$
  - $Q = 4.018\ kJ$

Total Energy