<u>Heat with Phase Change Worksheet</u>

1) How many joules are required to heat 250 grams of liquid water from 0^0 to 100^0 C ?

Phase	(J)/(g °C)		kJ/Mol
Gas	2.02	Boiling	40.65
Liquid	4.184		
Solid	2.0	Fusion	6.02

2) How many joules are required to melt 100 grams of water?

3) How many joules are required to boil 150 grams of water?

4) How many joules are required to heat 200 grams of water from 25 °C to 125°C?

5) How many joules are given off when 120 grams of water are cooled from 25°C to -25°C?

6) How many joules are required to heat 75 grams of water from -85°C to 185°C?

7) How many joules are required to heat a frozen can of juice (360 grams) from -5 °C (the temperature of an overcooled refrigerator) to 110°C (the highest practical temperature within a microwave oven)?

Heat with Phase Change Worksheet – Answer Sheet

1) How many joules are required to heat 250 grams of liquid water from 0^0 to 100^0 C ? **104.5 kJ**

$q = mC_p\Delta T$ $q = (250g)(4.18\ J/g^\circ C)(100^\circ C)$

q= ? **q = 104500 J = 104.5 kJ**

m= 250 g

C_p= 4.18 J/g°C

ΔT= 100°C - 0°C = 100°C

2) How many joules are required to melt 100 grams of water? **33.4 kJ**

$q = mH_f$ $q = (100g)(334\ J/g)$

q= ? **q = 33400 J = 33.4 kJ**

m= 100 g

H_f= 334 J/g

3) How many joules are required to boil 150 grams of water? **339 kJ**

$q = mH_v$ $q = (150g)(2260\ J/g)$

q= ? **q = 339000 J = 339 kJ**

m= 150 g

H_v= 2260 J/g

4) How many joules are required to heat 200 grams of water from 25°C to 125°C? **524.8 kJ**

Start with Specific Heat because the water is not going through a phase change.

$q = mC_p\Delta T$ $q = (200g)(4.18\ J/g^\circ C)(75^\circ C)$

q= ? **q = 62700 J = 62.7 kJ**

m= 200 g

C_p= 4.18 J/g°C

$\Delta T = |100^\circ C - 25^\circ C| = 75^\circ C$

Next, the water boils so you use Heat of Vaporization.

$q = mH_v$ $q = (200g)(2260\ J/g)$

q= ? **q = 452000 J = 452 kJ**

m= 200 g

H_v= 2260 J/g

Last, the steam heats up from 0°C to 125°C so use Specific Heat again, but use the constant for steam.

$q = mC_p\Delta T$ $q = (200g)(2.02\ J/g^\circ C)(25^\circ C)$

q= ? **q = 10100 J = 10.1 kJ**

m= 200 g

C_p= 2.02 J/g°C

ΔT= 125°C - 100°C = 25°C

Now, add the amount of heat (q) from each part of the answer.

Total heat (q_{Total}) = 62.7 kJ + 452 kJ + 10.1 kJ = 524.8 kJ

5) How many joules are given off when 120 grams of water are cooled from 25 °C to -25°C?
58.77 kJ
Start with Specific Heat because the water is not going through a phase change.

$q = mC_p\Delta T$ q = (120g)(4.18 J/g°C)(-25°C)
q= ? q = **12540 J = 12.54 kJ**
m= 120 g
C_p= 4.18 J/g°C
$\Delta T = |0°C - 25°C| = 25°C$

Next, the water freezes so you use Heat of Fusion.

$q = mH_f$ q = (120g)(334 J/g)
q= ? q = **40080 J = 40.08 kJ**
m= 120 g
H_f= 334 J/g

Last, the ice cools down from 0°C to -25°C so use Specific Heat again, but use the constant for ice.

$q = mC_p\Delta T$ q = (120g)(2.05 J/g°C)(-25°C)
q= ? **q = -6150 J = -6.15 kJ**
m= 120 g The number here is negative because heat is released.
C_p= 2.05 J/g°C
$\Delta T = |- 25°C - 0°C| = -25°C$

Now, add the amount of heat (q) from each part of the answer.
Total heat (q_T) = 12.54 kJ + 40.08 kJ + 6.15 kJ = **58.77 kJ**

6) How many joules are required to heat 75 grams of water from -85 °C to 185°C? **251.845 kJ**
Start with Specific Heat because the water is frozen and must heat up from -85°C to 0°C before it can go through a phase change.

$q = mC_p\Delta T$ q = (75g)(2.05 J/g°C)(85°C)
q = ? q = **13068.75 J = 13.068 kJ**
m= 75 g
C_p= 2.05 J/g°C
$\Delta T = |0°C - (-85°C)| = 85°C$

Next, the ice melts so you use Heat of Fusion.

$q = mH_f$ q = (75g)(334 J/g)
q= ? q = **25050 J = 25.05 kJ**
m= 75 g
H_f= 334 J/g

Next, the water heats up from 0°C to 100°C so use Specific Heat again, but use the constant for liquid.

$q= mC_p\Delta T$ q = (75g)(4.18 J/g°C)(100°C)
q= ? q = **31350 J = 31.35 kJ**
m= 75 g
C_p= 4.18 J/g°C
ΔT= 100°C - 0°C = 100°C

Next, the water boils so you use Heat of Vaporization.

$q = mH_v$ | $q = (75g)(2260\ J/g)$
$q = ?$ | $q =$ **169500 J = 169.5 kJ**
$m = 75\ g$
$H_f = 2260\ J/g$

Last, the steam heats up from 100˚C to 185˚C so use Specific Heat again, but use the constant for steam.

$q = mC_p\Delta T$ | $q = (75g)(2.02\ J/g˚C)(85˚C)$
$q = ?$ | $q =$ **12877.5 J = 12.877 kJ**
$m = 75\ g$
$C_p = 2.02\ J/g˚C$
$\Delta T = 185˚C - 100˚C = 85˚C$

Now, add the amount of heat (q) from each part of the answer.

Total heat (q_T) = 13.068 kJ + 25.05 kJ + 31.35 kJ + 169.5 kJ + 12.877 kJ = **251.845 kJ**

7) How many joules are required to heat a frozen can of juice (360 grams) from -5 ˚C (the temperature of an overcooled refrigerator) to 110˚C (the highest practical temperature within a microwave oven)?

1095.282 kJ

Start with Specific Heat because the water is frozen and must heat up from -5˚C to O˚C before it can go through a phase change.

$q = mC_p\Delta T$ | $q = (360g)(2.05\ J/g˚C)(5˚C)$
$q = ?$ | **q = 3690 J = 3.69 kJ**
$m = 360\ g$
$C_p = 2.05\ J/g˚C$
$\Delta T = 0˚C – (-5˚C) = 5˚C$

Next, the ice melts so you use Heat of Fusion.

$q = mH_f$ | $q = (360g)(334\ J/g)$
$q = ?$ $m = 360\ g$ $H_f = 334\ J/g$ | $q =$ **120240 J = 120.24 kJ**

(#8 cont.)

Next, the water heats up from 0˚C to 100˚C so use Specific Heat again, but use the constant for liquid.

$q = mC_p\Delta T$ | $q = (360g)(4.18\ J/g˚C)(100˚C)$
$q = ?$ | **q = 150480 J = 150.48 kJ**
$m = 360\ g$
$C_p = 4.18\ J/g˚C$
$\Delta T = 100˚C - 0˚C = 100˚C$

Next, the water boils so you use Heat of Vaporization.

$q = mH_v$ | $q = (360g)(2260\ J/g)$
$q = ?$ | **q = 813600 J = 813.6 kJ**
$m = 360\ g$
$H_f = 2260\ J/g$

Last, the steam heats up from 100˚C to 110˚C so use Specific Heat again, but use the constant for steam.

$q = mC_p\Delta T$

q= ?

m= 360 g

C_p= 2.02 J/g˚C

ΔT= 110˚C - 100˚C = 10˚C

q = (360g)(2.02 J/g˚C)(10˚C)

q = 7272 J = 7.272 kJ

Now, add the amount of heat (q) from each part of the answer.

Total heat (q_T) = 3.69 kJ + 120.24 kJ + 150.48 kJ + 813.6 kJ + 7.272 kJ = **1095.282 kJ**