Name: KEY Date: Hour:

Phase Change Worksheet

1) A 12 oz. can of soda weighs about 450 grams. How many joules are released when a can of soda is cooled from 25 degrees Celsius (room temperature) to 4 degrees Celsius (the temperature of a refrigerator). **The heat capacity of liquid water is 4.18 J / gram x °C.**

$m = 450g$
$Q = ?$
$T_1 = 25°C$
$T_2 = 4°C$
$\Delta T = 21°C$
$C = 4.18\ J/g°C$

$Q = m \times \Delta T \times C$

$Q = (450g)(21°C)(4.18\ J/g°C)$

$Q = 39,501\ J$

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

$Q = ?$
$m = 250g$
$\Delta T = 100°C$
$C = 4.18\ J/g°C$

$Q = m \times \Delta T \times C$

$Q = (250g)(100°C)(4.18\ J/g°C)$

$Q = 104,500\ J$

3) How many joules are required to melt 100 grams of water? **The heat of fusion of water is 6.01 kJ/mole.**

$m = 100g$
$\Delta H_{fus} = 6.01\ KJ/mol$

$q = \frac{m}{m_m} \Delta H_{fus}$

$q = \frac{100g}{18.01\ g/mol}(6.01\ KJ/mol)$

$q = 33.37\ KJ$

4) How many joules are required to boil 150 grams of water? **The heat of vaporization of water is 40.67 kJ / mole.**

$Q = ?$
$m = 150g$
$\Delta H_{vap} = 40.67\ KJ/mol$

$q = \frac{m}{m_m}(\Delta H_{vap})$

$q = \frac{150g}{18.01\ g/mol}(40.67\ KJ/mol)$

$q = 338.7\ KJ$

5) How many joules are required to heat 200 grams of water from 25 °C to 125 °C? **The heat capacity of steam is 1.84 J / g · °C**

$Q = ?$
$m = 200g$

① water 25°C → water 100°C

$Q = m \times \Delta T \times C$

$Q = (200g)(75°C)(4.18\ J/g°C)$

$Q = 62,700\ J = 62.7\ KJ$

② water 100°C → steam 100°C

$q = \frac{m}{m_m} \Delta H_{vap}$

$q = \frac{200g}{18\ g/mol}(40.67\ KJ/mol) = 451.64\ KJ$

③ steam 100°C → steam 125°C

$Q = m \times \Delta T \times C$

$Q = (200g)(25°C)(1.84\ J/g°C) = 9.2\ KJ$

$Q_{tot} = ① + ② + ③$

$Q_{tot} = 62.7\ KJ + 451.64\ KJ + 9.2\ KJ = 523.54\ KJ$

6) How many joules are given off when 120 grams of water are cooled from 25 ^{0}C to -25^{0}C? **The heat capacity of ice is 2.09 J / g $\cdot$ ^{0}C.**

$m = 120g$

① water 25°C → water 0°C

$Q = m \times \Delta T \times C$

$Q = (120g)(25°C)(4.18 J/g°C)$

12.54 KJ

② water 0°C → ice 0°C

$q = \frac{m}{mm} \Delta H_{fus}$

$q = \frac{120g}{18.01 g/mol}(6.01 KJ/mol)$

$q = 40.07 KJ$

③ ice 0°C → ice -25°C

$Q = m \times \Delta T \times C$

$Q = (120g)(25°C)(2.09 J/g°C)$

$Q = 6.27 KJ$

$q = 58.88 KJ$

7) How many joules are required to heat 75 grams of water from -85 ^{0}C to 185^{0}C? **The heat capacity of steam is 1.84 J / g $\cdot$ ^{0}C.**

$m = 75g$

① ice -85°C → ice 0°C

$Q = m \times \Delta T \times C$

$Q = (75g)(85°C)(2.09 J/g°C)$

$Q = 13.32 KJ$

② ice 0°C → water 0°C

$q = \frac{m}{mm} \Delta H_{fus}$

$q = \frac{75g}{18 g/mol}(6.01 KJ/mol)$

$q = 25.04 KJ$

③ water 0°C → water 100°C

$Q = m \times \Delta T \times C$

$Q = (75g)(100°C)(4.18 J/g°C)$

$Q = 31.35 KJ$

④ water 100°C → steam 100°C

$q = \frac{m}{mm} \Delta H_{vap}$

$q = \frac{75g}{18 g/mol}(40.67 KJ/mol)$

$q = 169.36 KJ$

⑤ steam 100°C → steam 185°C

$Q = m \times \Delta T \times C$

$Q = (75g)(85°C)(1.84 J/g°C)$

$Q = 11.73 KJ$

Tot = 250.8 KJ

8) How many joules are required to heat a ~~frozen~~ can of juice (360 grams) from -5 ^{0} C (the temperature of an overcooled refrigerator) to 110 ^{0}C (the highest practical temperature within a microwave oven)?

① ~~ice~~ -5°C → ~~water~~ 0°C

$Q = m \times \Delta T \times C$

$Q = (360g)(5°C)(2.09 J/g°C)$

$Q = 3.762 KJ$

② ice 0°C → water 0°C

$q = \frac{m}{mm} \Delta H_{fus}$

$q = \frac{360g}{18 g/mol}(6.01 KJ/mol)$

$q = 120.2 KJ$

③ water 0°C → water 100°C

$Q = m \times \Delta T \times C$

$Q = (360g)(100°C)(4.18 J/g°C)$

$Q = 150.480 KJ$

④ water 100°C → steam 100°C

$q = \frac{m}{mm} \Delta H_{vap}$

$q = \frac{360g}{18 g/mol}(40.67 KJ/mol)$

$q = 813.4 KJ$

⑤ steam 100°C → steam 110°C

$Q = m \times \Delta T \times C$

$Q = (360g)(10°C)(1.84 J/g°C)$

$Q = 6.624 KJ$

Tot Q = 1094.5 KJ

9) How many joules are released when 450 grams of water are cooled from 4 x 10^7 K (the hottest temperature ever achieved by man) to 1 x 10^{-9} K (the coldest temperature achieved by man).

① Steam 4×10^7 K → steam 373K

$Q = m \times \Delta T \times C$

$Q = (4 \times 10^7)(450g)(1.84 J/g°C)$

$Q = 3.312 \times 10^{10}$ KJ

② Steam 373K → water 373K

$q = \frac{m}{mm} \Delta H_{vap}$

$q = \frac{450g}{18 g/mol}(40.67 KJ/mol)$

$q = 1016.75 KJ$

③ water 373 → water 273K

$Q = m \times \Delta T \times C$

$Q = (450g)(100K)(4.18 J/gK)$

$Q = 188.1 KJ$

④ water 273K → ice 273K

$q = \frac{m}{mm}(\Delta H_{fus})$

$q = \frac{450g}{18 g/mol}(6.01 KJ/mol)$

$q = 150.25 KJ$

⑤ ice 273K → ice at 1×10^{-9} K

$Q = m \times \Delta T \times C$

$Q = (450g)(273)(2.09 J/gK)$

$Q = 256.757 KJ$

$Q_{tot} = 3.312 \times 10^7$ KJ

10) How many joules are required to ~~raise the temperature~~ of 100 grams of water from -269 ^{0}C (the current temperature of space) to 1.6 x 10^{15} ^{0}C (the estimated temperature of space immediately after the big bang)?