1. A 79 gram sample of water at 21°C is heated until it becomes steam with a

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* Phase changes are taking place – multistep problem!

Step 1: heat water from 21°C to 100°C

$$Q = (4.184)(79)(79)$$

$$Q = 26112.344\ J$$

Step 2: Change water to steam at 100

$$\frac{79\,g}{} \bigg| \frac{40.61\,kJ}{18\,g} = \frac{178.1889\,kJ}{} \bigg| \frac{1 \times 10^3\,J}{1\,kJ} = 178188.9\,J$$

Step 3: Total Energy from each step.

$$26112.344 + 178188.9 = 204301.244\,J = 2.0 \times 10^5\,J$$

2. A 445 gram sample of ice at -58°C is heated until the temperature reaches -29°C.

No phase Changes - $Q = s \times m \times \Delta T$

$Q = (2.09)(445)(29)$

$Q = 26971.45\ J$

rounded to proper sig. figs. 27000 J

3. A 12 oz can of soda weighs 450 grams. Soda is mostly water. How many joules of energy are released when a can of soda is cooled from 25°C (room temperature) to 4°C

No Phase Changes – $Q = S \times m \times \Delta T$

$Q = (4.184)(450)(21)$

$Q = 39\bar{5}38.8\ J$

rounded to proper sig. figs. $40000\ J$

4. How many kilojoules of energy are required to heat 250 grams of water from

No Phase Changes - $Q = s \times m \times \Delta T$

Asks for Answer in Kilojoules!

$Q = (4.184)(250)(100)$

$Q = 104600\ J$

$\frac{104600\ J}{} \left| \frac{1\ kJ}{1 \times 10^3\ J} \right. = 104.600\ kJ$

rounded to proper sig. figs. $1.0 \times 10^2\ kJ$

5. How many joules of energy are required to melt 100.00 grams of ice?

Only a phase change is required

Note - Answer must be in joules!

$$\frac{100.00\,g \mid 6.02\,KJ}{\mid 18\,g} = 33.444\,KJ$$

$$\frac{33.444\,KJ \mid 1\times10^3\,J}{\mid 1\,KJ} = 33444\,J$$

rounded to proper sig. figs. 33444 J

6. How many kilojoules of energy are required to boil 150 grams of water into

Only a phase change is required

Note - Answer must be in Kilojoules!

$$\frac{150\,g \;|\; 40.6\,kJ}{\;|\; 18\,g} = 338.333\,kj$$

rounded to proper sig. figs. **300 kJ**

7. A 125 gram sample of ice at -20.0°C is heated until it changes to steam at 150°C.

Multiple Phase changes + answer must be in joules!

Step 1: heat ice to 0°C

$Q = (2.09)(125)(20°C)$

$Q = 5225\ J$

Step 2: Change Ice to water at 0°C

$$\frac{125\ g \mid 6.02\ kJ}{\mid 18\ g} = \frac{41.80556\ kJ \mid 1 \times 10^3\ J}{\mid 1\ kJ} = 41805.56\ J$$

Step 3: heat water to 100°C

$Q = (4.184)(125)(100)$

$Q = 52300\ J$

#7 continued

Step 4: Vaporize water to steam at 100°C

$$\frac{125\,g}{} \left| \frac{40.6\,kJ}{18\,g} \right. = \frac{281.9444\,kJ}{} \left| \frac{1\times10^{3}\,J}{1\,kJ} \right. = 281944.4\,J$$

Step 5: Heat steam to 150°C

$Q = (1.84)(125)(50)$

$Q = 11500\,J$

Step 6: Add energy from each step to find total

$5225 + 41805.56 + 52300 + 281944.4 + 11500 = 392775\,J$

rounded to proper sig. figs. **390000 J**

8. How many joules of energy are given off when 120. grams of water are cooled

Phase Changes + answer in joules

Step 1: Cool water from 25 °C to 0 °C

$Q = (4.184)(120)(25)$

$Q = 12552\ J$

Step 2: Change water to ice at 0 °C

$\frac{120\ g \mid 6.02\ kJ}{\mid 18\ g} = \frac{25.083\ kJ \mid 1\times10^3\ J}{\mid 1\ kJ} = 25083\ J$

Step 3: Cool Ice to −25 °C

$Q = (2.09)(120)(25)$

$Q = 6270\ J$

Step 4: Total all steps

$12552 + 25083 + 6270 = 58955\ J$

Proper Sig. Figs. **59000 J**

9. How many kilojoules of energy are given off when 340 grams of water are

Multiple phase changes + answer in kilojoules.

Step 1: Cool steam from 150 °C to 100 °C

$Q = (4.184)(340)(50)$

$Q = \frac{71128\ J}{} \Big| \frac{1\ kJ}{1 \times 10^3\ J} = 71.128\ kJ$

Step 2: Change steam to water at 100 °C

$\frac{340\ g}{} \Big| \frac{40.6\ kJ}{18\ g} = 766.889\ kJ$

Step 3: Cool water from 100 °C to 0 °C

$Q = (4.184)(340)(100)$ $Q = \frac{142256\ J}{} \Big| \frac{1\ kJ}{1 \times 10^3\ J} = 142.256\ kJ$

#9 continued

Step 4: Change water to ice at 0°C

$$\frac{340\,g}{} \left| \frac{6.02\,kJ}{18\,g} \right. = 113.7111\ kJ$$

Step 5: Cool ice at 0°C to -35°C

$$Q = (2.09)(340)(35)$$

$$Q = \frac{24871\,J}{} \left| \frac{1\,kJ}{1 \times 10^3\,J} \right. = 24.871\ kJ$$

Step 6: Total energy from each step.

$$71.128 + 766.889 + 142.256 + 113.7111 + 24.871 = 1118.8551\ kJ$$

rounded to proper sig. figs. **1100 kJ**

10. How many joules of energy are required to heat 360 grams of frozen juice

Phase changes and answer in joules.

Step 1: heat from -5°C to 0°C

$Q = (2.09)(360)(5)$

$Q = 3762\ J$

Step 2: Change ice to water at 0°C

$\frac{360\ g}{} \left| \frac{6.02\ kJ}{18\ g} \right. = \frac{120.4\ kJ}{} \left| \frac{1 \times 10^3\ J}{1\ kJ} \right. = 120400\ J$

Step 3: heat water from 0°C to 100°C

$Q = (4.184)(360)(100)$

$Q = 150624\ J$

10 Continued

Step 4: Change water to steam at 100°C

$$\frac{360\,g}{} \Big| \frac{40.6\,kJ}{18\,g} = \frac{812\,kJ}{} \Big| \frac{1\times10^{3}\,J}{1\,kJ} = 812000\,J$$

Step 5: heat steam from 100°C to 110°C

$$Q = (1.84)(360)(10)$$

$$Q = 6624\,J$$

Step 6: Total energy from each step.

$$3762 + 120400 + 150624 + 812000 + 6624 = 362610\,J$$

rounded to proper sig. figs. = $400000\,J$

11. How many joules of energy are required to heat 45 grams of water from -205°C

Phase changes and answer in joules.

Step 1: heat ice from -205°C to 0°C

$Q = (2.09)(45)(205)$

$Q = 19280.25\ J$

Step 2: Change ice to water at 0°C

$\frac{45\,g}{} \Big| \frac{6.02\,kJ}{18\,g} = \frac{15.05\,kJ}{} \Big| \frac{1\times10^{3}\,J}{1\,kJ} = 15050\ J$

Step 3: Heat water at 0°C to 100°C

$Q = (4.184)(45)(100)$ $Q = 18828\ J$

11 continued

Step 4: Change water to steam at 100°C

$$\frac{45\,g \mid 40.6\,kJ}{\mid 18\,g} = \frac{101.5\,kJ \mid 1\times10^{3}\,J}{\mid 1\,kJ} = 101500\,J$$

Step 5: heat steam from 100°C to 150°C

$Q = (1.84)(45)(50)$

$Q = 4140\,J$

Step 6: Total energy from each step.

$19280.25 + 15050 + 18828 + 101500 + 4140 = 158798.25\,J$

rounded to proper sig. figs = $160000\,J$

12. How many joules of energy are required to heat 200. grams of water from 25°C

Phase change and answer in joules

Step 1: heat water from 25°C to 100°C

$Q = (4.184)(200)(75)$

$Q = 62760$ J

Step 2: Change water to steam at 100°C

$\frac{200\ g}{18\ g} \times \frac{40.6\ kJ}{} = 451.111\ kJ \times \frac{1 \times 10^3\ J}{1\ kJ} = 451111\ J$

Step 3: heat steam from 100°C to 125°C

$Q = (1.84)(200)(25)$ $Q = 9200$ J

Step 4: Total Energy from Each Step

$62760 + 451111 + 9200 = 523071$ J

rounded to proper sig fig.

520000 J

13. A 235 gram sample of aluminum gains 2500 joules of energy. If the sample's

no phase change   solving for ΔT initial + ΔT = final

$$2500 = (0.890)(235)(\Delta T)$$

$$\frac{2500}{209.15} = \frac{209.15}{209.15}(\Delta T)$$

$$\Delta T = 11.95314368$$

$$10.0 + 11.953 = 21.953$$

rounded to proper sig. fig. 22°C

14. A 459 gram sample of water reaches a temperature of 87°C with the addition of

no phase change solving for ΔT final $- \Delta T =$ initial

$$3567 = (4.184)(459)(\Delta T)$$

$$\frac{3567}{1920.456} = \frac{1920.456(\Delta T)}{1920.456}$$

$$\Delta T = 1.857371374$$

$$87 - 1.857 = 85.14$$

rounded to proper sig. fig. 85°C

15. A sample of iron with an unknown mass is heated from 45°C to 85°C using 780

no phase change solving for m

$$780 = (0.445)(m)(40)$$

$$\frac{780}{17.8} = \frac{17.8\,(m)}{17.8}$$

$$m = 43.82022472$$

rounded to proper sig. fig. 44 J

16. A 240. gram sample of water, initially at 20.0°C, is mixed with an unknown mass of iron, initially at a temperature of 500°C. When the temperature equalizes, the system (iron + water) has a temperature of 42°C. What is the mass of the iron that

determine amt. of energy - apply to second substance

$Q = (4.184)(240)(22)$

$Q = 22091.52\ J$

$22091.52 = (0.445)(m)(458)$

$\frac{22091.52}{203.81} = \frac{203.81(m)}{203.81}$

$m = 108.3927187\ g$

rounded to proper sig figs

$100\ g$

17. A 350 gram sample of water, initially at 25.3 °C, is mixed with a 300 gram sample of aluminum. The temperature of the equalized system (water + aluminum) is 58.2° C. What was the initial temperature of the aluminum sample?

determine amt. of energy - apply to second substance

$Q = (4.184)(350)(32.9)$

$Q = 48178.76$

$48178.76 = (0.890)(300)(\Delta T)$

$\frac{48178.76}{267} = \frac{267(\Delta T)}{267}$

final + ΔT = initial

$\Delta T = 180.444$

238.644 °C

Proper Sig. figs. **200 °C**

18. A 800 gram sample of water is mixed with a 250 gram sample of iron that has an initial temperature of 85°C. The equalized temperature of the system (water + iron)

$Q = (0.445)(250)(35)$

$Q = 3893.75\ J$

$3893.75 = (4.184)(800)(\Delta T)$

$\frac{3893.75}{3347.2} = \frac{3347.2(\Delta T)}{3347.2}$

$\Delta T = 1.163285731$

$final - \Delta T = initial$

$50 - 1.1633 = 48.8367\ °C$

rounded to proper sig figs:

50°C

19. If a 25 grams sample is heated with 2.5 kilojoules of energy and the temperature of the sample changes from 20.0°C to 75°C, is the sample pure gold?

$$2.5\ kJ \times \frac{1\times10^3\ J}{1\ kJ} = 2500\ J$$

$$2500 = (S)(25)(55)$$

$$\frac{2500}{1375} = (S)\frac{1375}{1375}$$

$$1.81818 = S$$

S for pure gold = 0.13

No - The sample cannot be pure gold.

20. If you are holding an aluminum rod in one hand and an iron rod in the other, which rod will warm to your external body temperature first? Both rods have the same mass and starting temperature. Explain your answer.

The iron will heat up to my surface body temperature first because it takes fewer joules of energy to heat iron (0.445 J/g°C) than it does to heat aluminum (0.890 J/g°C). The iron would heat nearly twice as quickly because it requires approximately half the energy as aluminum.