Welcome to our CHEM 4 lecture

Review clicker question: Heat capacity calculations

Go to LearningCatalytics.com Session ID = 45667976

1) How many kcal (to 3 sig figs) are required to raise the temperature of 35.0 mL of alcohol from 23.0 °C to 45.0 °C? The density of alcohol = 0.789 g/mL and its specific heat capacity = 2.14 J/g °C.

A) 59.6 kcal

B) 1.30 x 10^3 kcal

C) 0.311 kcal

D) 311 kcal

E) 0.0596 kcal

F) 3.30 x 10^3 kcal

$$C = \frac{q}{m\,(T_f - T_i)}$$

See answer worked out on next slide

Work shown for previous question

1) How many kcal (to 3 sig figs) are required to raise the temperature of 35.0 mL of alcohol from 23.0 °C to 45.0 °C? The density of alcohol = 0.789 g/mL and its specific heat capacity = 2.14 J/g °C.

Answer:

- *Rearrange equation:* $q = m\,C\,\Delta T$
- *Collect m, C and Δ T with right units. Use units for C (**J/g °C**) to guide you.*
  - $C_{alcohol}$ = 2.14 J/g °C *3sf*
  - $m = (35.0\ \text{mL})\left(\frac{0.789\ \text{g}}{1\ \text{mL}}\right) = 27.62\ \text{g}$ *3sf*
  - $\Delta T = T_f - T_i$ = 45.0 °C – 23.0 °C = 22.0 °C *3sf*
- *Calculation:*

3sf *3sf* *3sf*

$q = m\,C\,\Delta T = (27.62\ \text{g})(2.14\ \text{J/g °C})(22.0\ \text{°C}) = 1300.3496\ \text{J}$

$= 1300.3496\ \text{J}\left(\frac{1\ \text{cal}}{4.184\ \text{J}}\right)\left(\frac{1\ \text{kcal}}{1000\ \text{cal}}\right) = 0.310791013\ \text{kcal} = \mathbf{0.311\ kcal}$

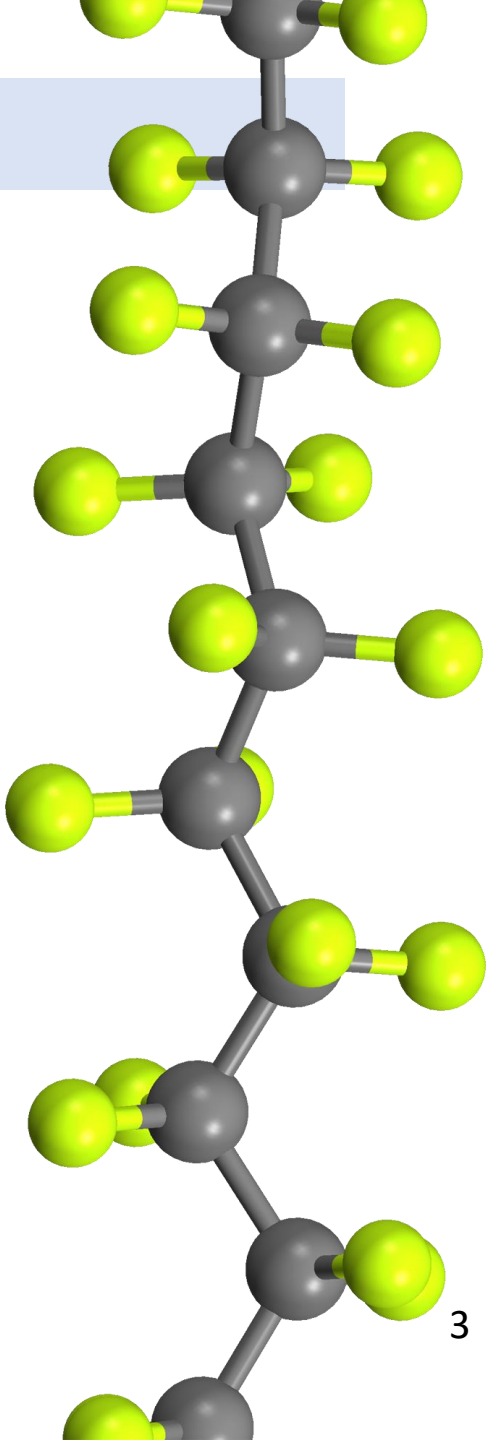
3sf *∞ sf* *∞ sf* *Keep 3sf*

Exam #2: Information

- **Exam #2 is Friday, October 30.**
  - During normal class period. Go to Canvas to take the exam.
  - Timed: 50 minutes
  - 20 multiple choice questions; worth 5 pts each.
  - Both questions and answers will be randomized for each student.

  - Can use class handouts, textbook, lecture notes, PowerPoint slides.
  - Get all your materials (such as handouts, calculator and paper/pencil) ready before you start the exam.

  - Even though it is open book, you will not have enough time to look up every single thing, so you must study and be fully prepared going into the exam.



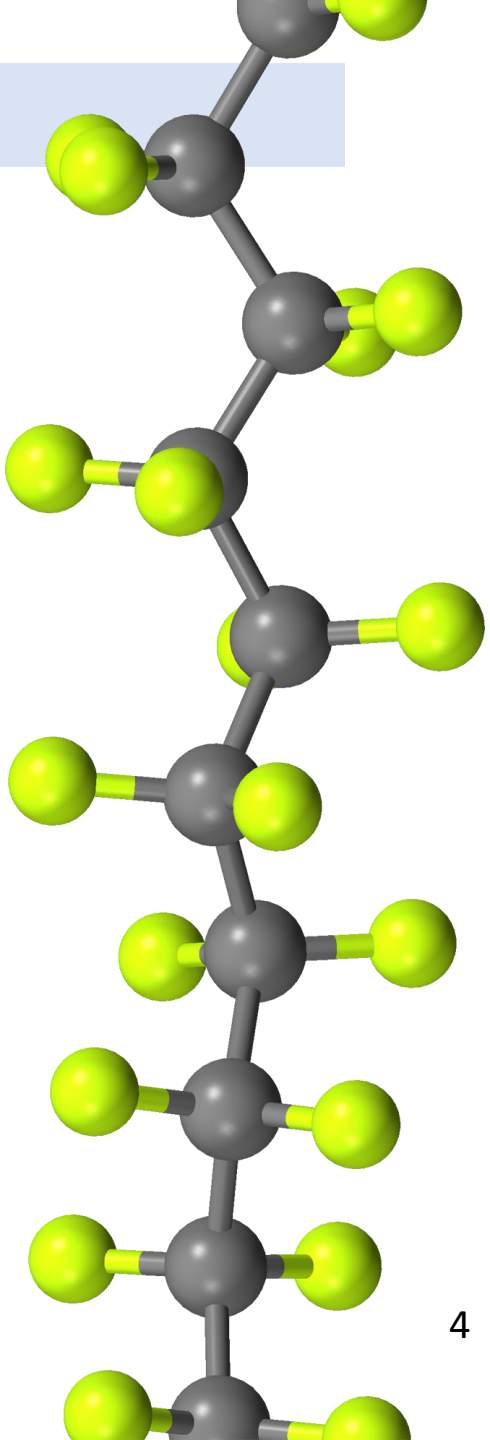
Exam #2: Resources

October calendar: tinyurl.com/SacStateChem4

- ✓ Learning Outcomes for Exam #2.
- ✓ PowerPoint slides and recordings of lecture.
- ✓ Practice exams, 4 versions: A, B, C, and D. [NOTE: they are not on Canvas]
  - ✓ Time yourself; take it like a real exam.
  - ✓ Make a list of the type of questions you are getting wrong and focus your study on those topics.
  - ✓ For extra practice on those topics, review: Video recording of lecture, PowerPoint slides, e-text, optional homework problems, PAL worksheets.
- ✓ Finish up any late homework for credit.

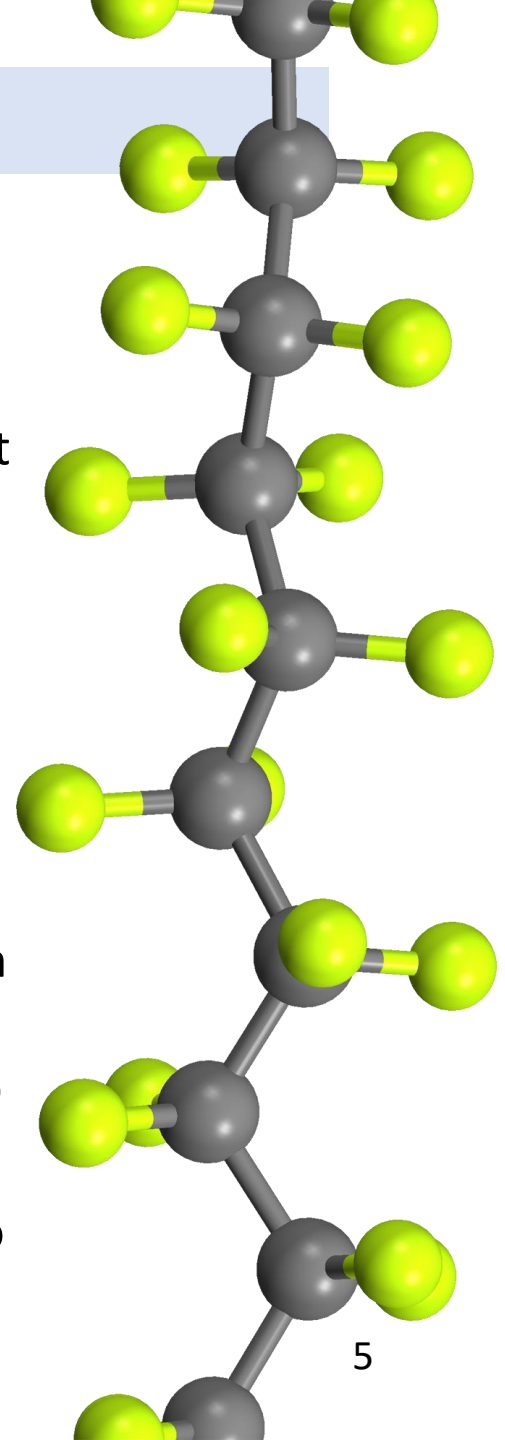
Need help?

- ✓ Jeff's office hours this week: **MW 9 – 9:30 am and 11 – 11:30 am**.
- ✓ Review session, Wednesday (10/28) during lecture: **Email me (jparadis@csus.edu) questions by 12 noon on Tuesday, 10/27.**
- ✓ PAL office hours: link is on our CHEM 4 website
- ✓ PAL study hall (open to all CHEM 4 students): **Tuesday, Oct 27th from 4-7 pm.** *Zoom code: 844 3244 0711*



Academic dishonesty:

- ✓ Cannot use any online resources that are not explicitly associated with class.
- ✓ Students posting to sites like Chegg or Bartleby are cheating.
- ✓ **Remember:** Everyone get's hurt by cheating:
  - ✓ Cheaters are stealing the hard work of others by taking a grade that they haven't earned.
  - ✓ Cheaters hurt themselves because they won't be prepared for our next exam or for CHEM 1A/1E, not to mention the MCAT, EIT, DAT, PCAT.
  - ✓ Cheaters risk getting caught and being brought up on disciplinary charges.
  - ✓ SacState's reputation is hurt when employers realize our grads don't know anything!
- ✓ **Bottom line:** There is no reason to cheat in this class. You are smart enough to earn a good grade. So, do your studying and be proud of the grade that you earn. If you end up earning a grade that you are not happy with, then do *Commit to Study*, drop the exam grade and make changes so you do better on the next exam.
- ✓ **My promise to you:** There will be no surprises and no trick questions. I just want to see if you have been learning the material that we've covered.



CHEM 4 lecture

Monday – October 26, 2020

Sec 3.12 continued…

Heat capacity

Background: Determining the Calorie content in foods

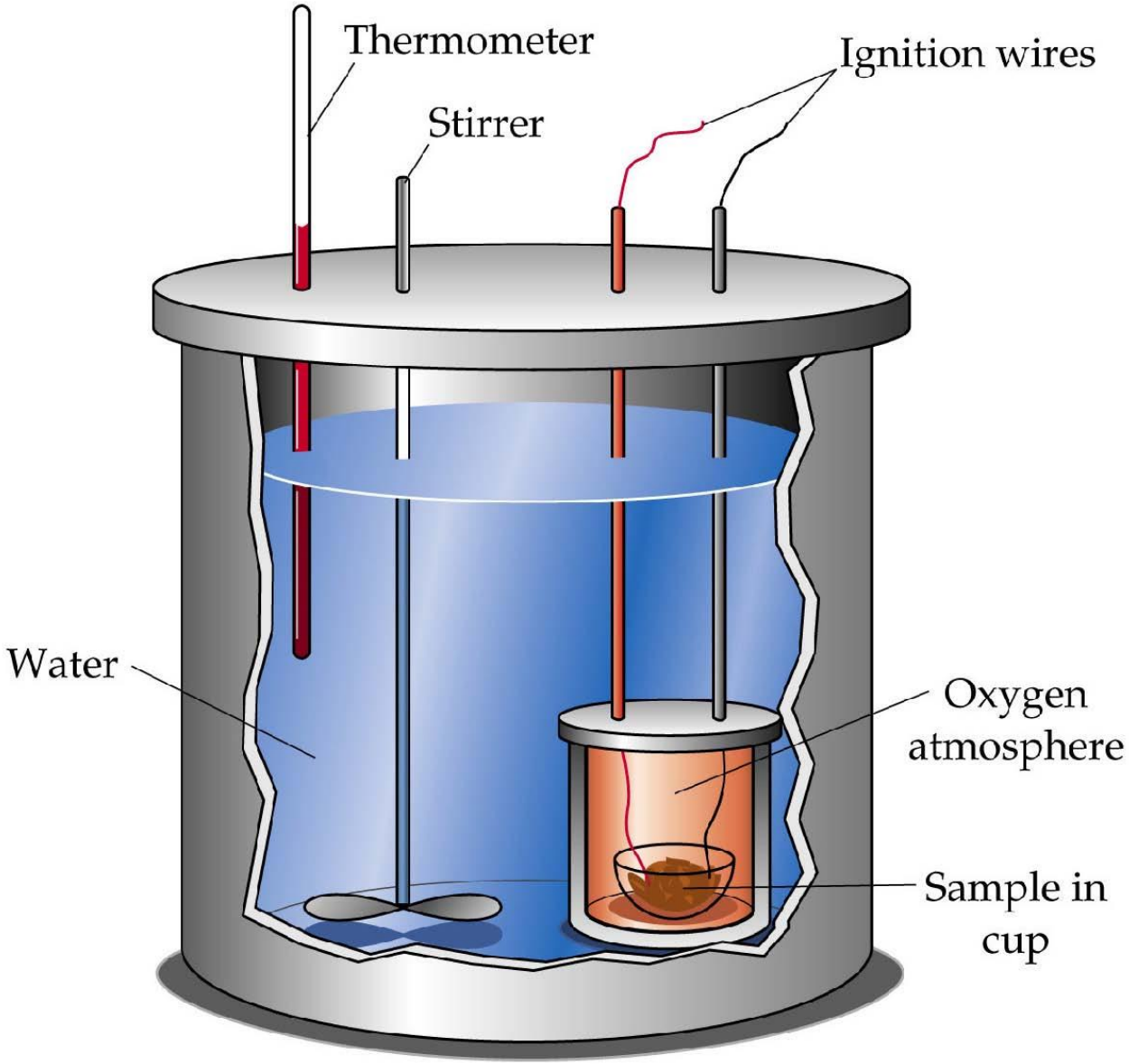
Nutrition Facts
Serving Size 1 Packet (28g)
Servings Per Container 12

Amount Per Serving	
Calories	100
Calories from Fat	20
	% Daily Value*
Total Fat 2g	**3%**
Saturated Fat 0g	**0%**
Trans Fat 0g	
Polyunsaturated Fat 0.5g	
Monounsaturated Fat 0.5g	
Cholesterol 0mg	**0%**
Sodium 80mg	**3%**
Potassium 105mg	**3%**
Total Carbohydrate 19g	**6%**
Dietary Fiber 3g	**11%**
Soluble Fiber 1g	
Sugars 0g	
Protein 4g	
Vitamin A	20%
Vitamin C	0%
Calcium	10%
Iron	40%
Thiamin	20%
Riboflavin	20%
Niacin	20%
Vitamin B_6	20%
Folic Acid	20%

How do scientists determine the Calorie content of foods?

They can use a bomb calorimeter.

Background: Bomb Calorimeter



- We know the mass of the water, the heat capacity of the water, and we can measure the temperature change for the water.
- So, we are able to calculate the amount of heat that the water gained.

$$q_{H2O} = (m_{H2O})(C_{H2O})(T_f - T_i)$$

- All of the heat came from the combustion of our sample.
- So, the heat gained by the water = the Calorie content of our food sample.

Progress clicker question: Determining the Calorie content in food using a bomb calorimeter

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2) If we burn 1 packet of oatmeal in a bomb calorimeter containing 5.00 kg water, and the temperature of the water increases from 23.0°C to 42.5°C, how many nutritional Calories does the packet of oatmeal contain?

A) 104 cal
B) 104 Cal
C) 408 cal
D) 408 Cal
E) 9.74×10^4 cal
F) 9.74×10^4 Cal
G) 97.4 cal
H) 97.4 Cal

$$C = \frac{q}{m\,(T_f - T_i)}$$

C_{H2O} = 4.18 J/g °C

Answer: $q_{water} = (m_{water})(C_{water})(\Delta T_{water}) = (m_{water})(C_{water})(T_f - T_i)$

$= (5.00 \times 10^3\ g)(4.18\ J/g\ °C)(42.5\ °C - 23.0\ °C)$

3sf 3sf 3sf 3sf

$= (5.00 \times 10^3\ \cancel{g})(4.18\ J/\cancel{g}\ \cancel{°C})(19.5\ \cancel{°C}) = 407550\ J$

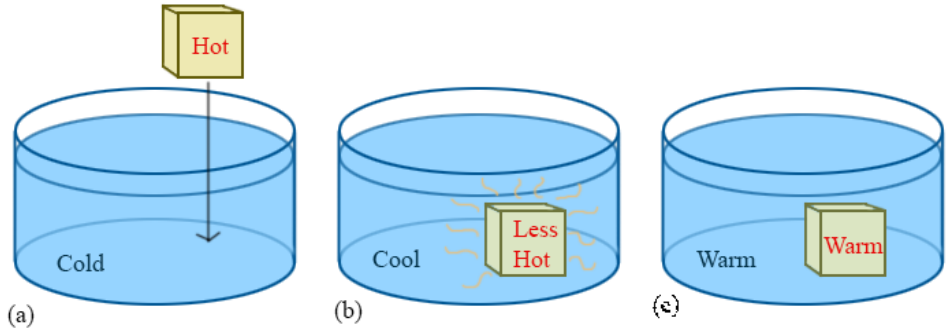
3sf ∞ sf ∞ sf keep 3sf

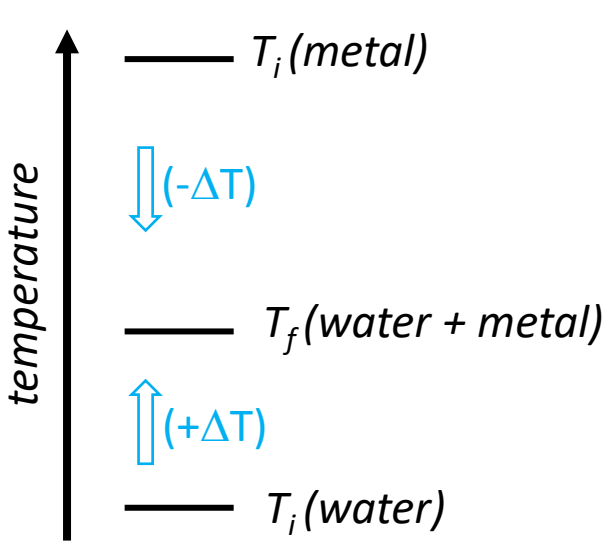
$= (407550\ \cancel{J})(1\cancel{cal}/4.184\ \cancel{J})(1\ Cal/1000\ \cancel{cal}) = 97.4\ Cal$

This is the heat the water absorbed, so it must be the Calories given off by the oatmeal.

Background: Determining heat capacity for a metal (Part 1)

- We can also use calorimetry to determine the heat capacity for metals. [Think of the data we used last class to calculate *C* for lead and aluminum.]
- Heat a piece of metal and drop it into water. Use the ΔT of the water to figure out how much heat the water absorbed (and therefore how much heat the metal released).





Start by heating the metal to get to T_i for the metal.

Eventually, both the water and metal come to the same T_f.

- After they reach the same T_f, the heat lost by the metal equals the heat gained by the water.

Background: Determining heat capacity for a metal (Part 2)

- We can therefore write:

$$q_{metal} = -q_{water}$$

The negative sign is require since one side is $-\Delta T$ and the other is $+\Delta T$.

Substitute both sides with: $q = mC\Delta T$

$$(m_{metal})(C_{metal})(T_{f,\,metal} - T_{i,\,metal}) = -(m_{H2O})(C_{H2O})(T_{f,\,H2O} - T_{i,\,H2O})$$

Progress clicker question: Determining the heat capacity of a metal
Go to LearningCatalytics.com Session ID = 45667976

3) While hiking in the Sierra, you find a shiny piece of metal weighing 415 g. You decide to determine the specific heat of the metal to see if it might be gold. You heat the metal to 164 °C and drop it in 200.0 g of water at 22.0 °C. The final temperature of the water and the metal is 46.2 °C. What is the heat capacity of the metal?

A) C_{metal} = 0.128 J/g °C

B) C_{metal} = 0.414 J/g °C

C) C_{metal} = 0.258 J/g °C

D) C_{metal} = 0.195 J/g °C

$q = mC\Delta T$

C_{H2O} = 4.18 J/g °C

Answer:

$q_{metal} = - q_{water}$

$(m_{metal})(C_{metal})(T_{f,\ metal} - T_{i,\ metal}) = - (m_{water})(C_{water})(T_{f,\ water} - T_{i,\ water})$

$(415\ g)(C_{metal})(46.2\ °C - 164\ °C) = - (200.0\ g)(4.18\ J/g\ °C)(46.2°C - 22.0\ °C)$

$(415\ g)(C_{metal})(-\underline{117}.8\ °C) = - (200.0\ \cancel{g})(4.18\ J/\cancel{g}\ \cancel{°C})(\underline{24.2}\ \cancel{°C})$

$(-\underline{48887}\ g\ °C)(C_{metal}) = -\underline{20231.2}\ J$

Keep 3sf C_{metal} = 0.414 J/g °C

Gold has a heat capacity = 0.128 J/g °C, so our mystery metal isn't gold. ☹

Progress clicker question: Performing calculations that use heat capacity

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4) A 20.0 g sample of copper is heated to 203 °C and dropped into 80.0 g of water at 25.0 °C. What is the final temperature of the water (to 3 sig figs)?

[Hint: both the copper and the water end up at the same final temperature, so T_f is the same variable on both sides of the equation.]

A) 19.9 °C
C) 20.9 °C
E) 155 °C
B) 29.0 °C
D) 43.5 °C
F) 30.4 °C

$q = mC\Delta T$

$C_{Cu} = 0.384$ J/g °C

$C_{H2O} = 4.18$ J/g °C

See answer worked out on next slide

Work shown for previous question

4) A 20.0 g sample of copper is heated to 203 °C and dropped into 80.0 g of water at 25.0 °C. What is the final temperature of the water (to 3 sig figs)?

Answer:

$$q_{copper} = -q_{water}$$

$$(m_{Cu})(C_{Cu})(T_{f,\,Cu} - T_{i,\,Cu}) = -(m_{water})(C_{water})(T_{f,\,water} - T_{i,\,water})$$

$$(20.0\text{ g})(0.384\text{ J/g°C})(T_{f,\,copper} - 203°C) = -(80.0\text{ g})(4.18\text{ J/g°C})(T_{f,\,water} - 25.0°C)$$

This would leave two variables, but since T_f is the same for both:

$$(20.0\text{ g})(0.384\text{ J/g °C})(T_f - 203°C) = -(80.0\text{ g})(4.18\text{ J/g °C})(T_f - 25.0°C)$$

$$(7.68\text{ J/°C})(T_f - 203°C) = -(334.4\text{ J/°C})(T_f - 25.0°C)$$

Distribute through ( ), and group like terms. Be careful with the "-" sign!!!

$$(7.68\text{ J/°C})(T_f) - 1559.04\text{ J} = -(334.4\text{ J/°C})(T_f) + 8360\text{ J}$$

$$(342.08\text{ J/°C})(T_f) = 9919.04\text{ J}$$

$$T_f = 28.996°C = 29.0°C$$