Welcome to our CHEM 4 lecture

Review clicker question: Energy calculations

Go to LearningCatalytics.com Session ID = 88787897

1) If Jane burns 2.5 MJ each hour while riding her bike along the American River trail, how many minutes will it take her to burn off a 345 Cal latte?

A) 2.0 min
B) 34.6 min
C) 0.58 min
D) 5.8×10^2 min
E) 35 min
F) 90. min
G) 3.5×10^{13} min
H) 87 min

Hint: Turn “2.5 MJ each hour” into a conversion factor

Answer: *Flowchart:* $\underbrace{\text{Cal} \rightarrow \text{cal} \rightarrow \text{J} \rightarrow \text{MJ}}_{\text{energy}} \xrightarrow{\text{2.5 MJ/hr}} \underbrace{\text{hr} \rightarrow \text{min}}_{\text{time}}$

Calculation:

$$\underset{3sf}{(345\ \cancel{\text{Cal}})} \underset{\infty\,sf}{\left(\frac{1000\ \cancel{\text{cal}}}{1\ \cancel{\text{Cal}}}\right)} \underset{\infty\,sf}{\left(\frac{4.184\ \cancel{\text{J}}}{1\ \cancel{\text{cal}}}\right)} \underset{\infty\,sf}{\left(\frac{1\ \cancel{\text{MJ}}}{10^6\ \cancel{\text{J}}}\right)} \underset{2sf}{\left(\frac{1\ \cancel{\text{hr}}}{2.5\ \cancel{\text{MJ}}}\right)} \underset{\infty\,sf}{\left(\frac{60\ \text{min}}{1\ \cancel{\text{hr}}}\right)} = \underset{\boxed{\text{Keep 2sf}}}{34.64352} = \mathbf{35\ min}$$

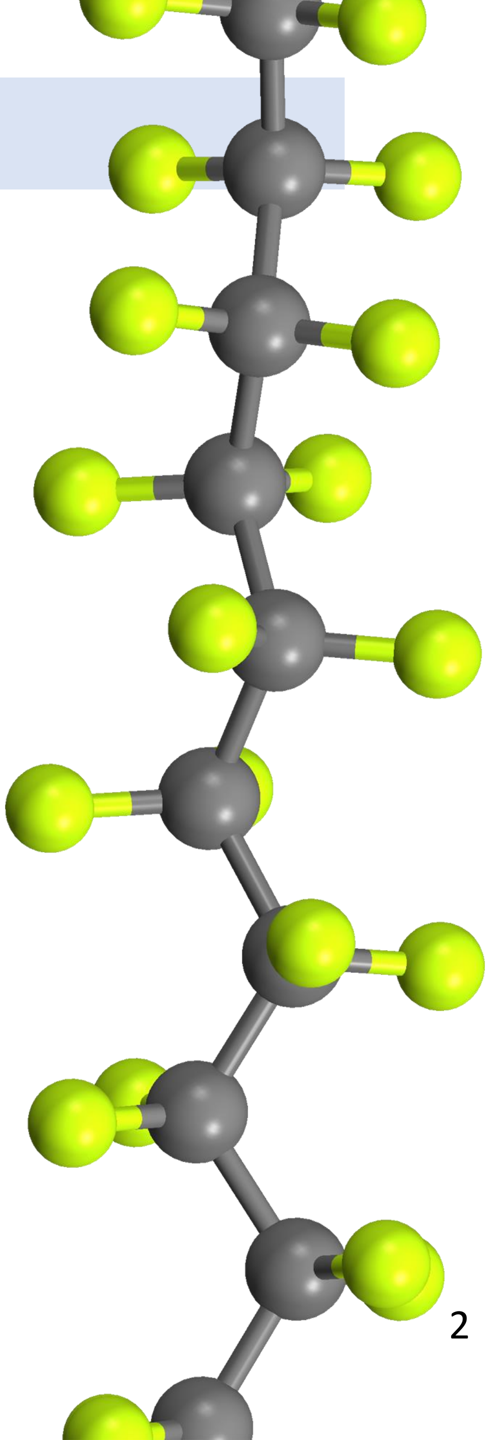
Exam #2: Information

✓ **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.



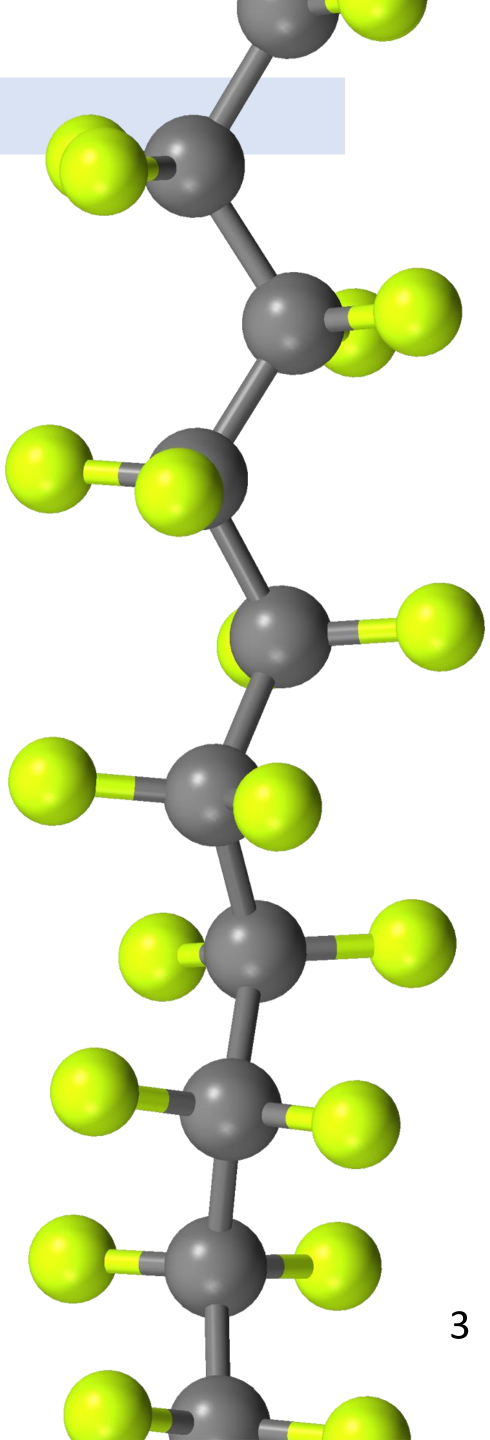
Exam #2: Resources

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.

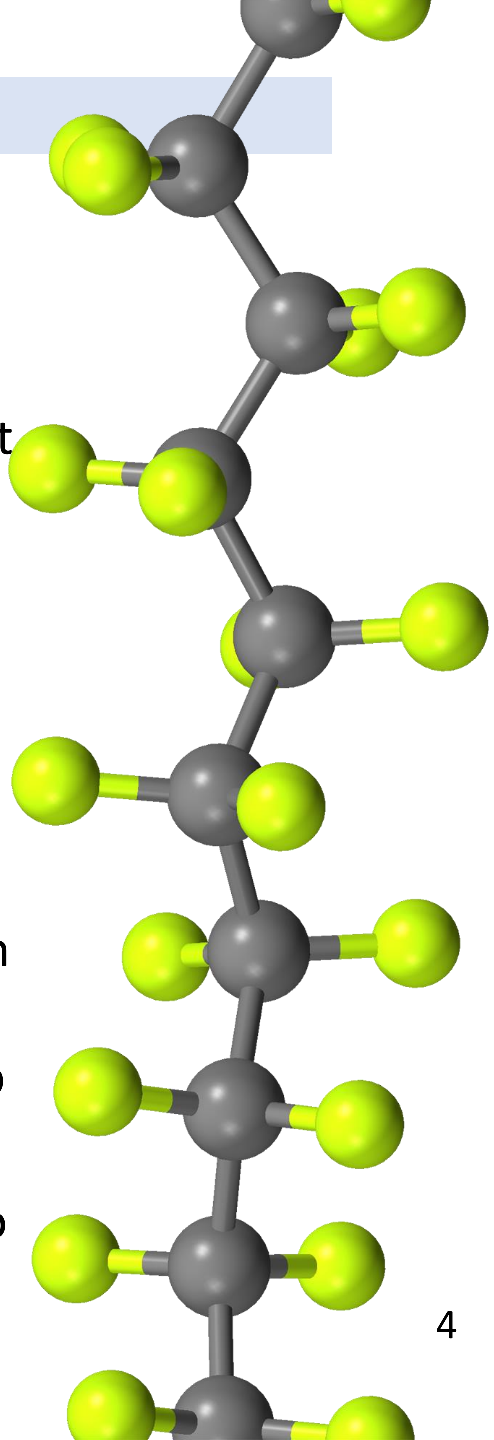
Need help?

- ✓ Review session, Wednesday (10/28) during lecture: **Email me (jparadis@csus.edu) questions by 12 noon on Tuesday, 10/27.**
- ✓ Jeff's office hours: MWF 9 – 9:30 am and 11 – 11:30 am; and by appointment
- ✓ 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

Friday – October 23, 2020

Sec 3.11 – 3.12

Heat capacity

Reading clicker question: Sec 3.11 – 3.12

Go to LearningCatalytics.com Session ID = 88787897

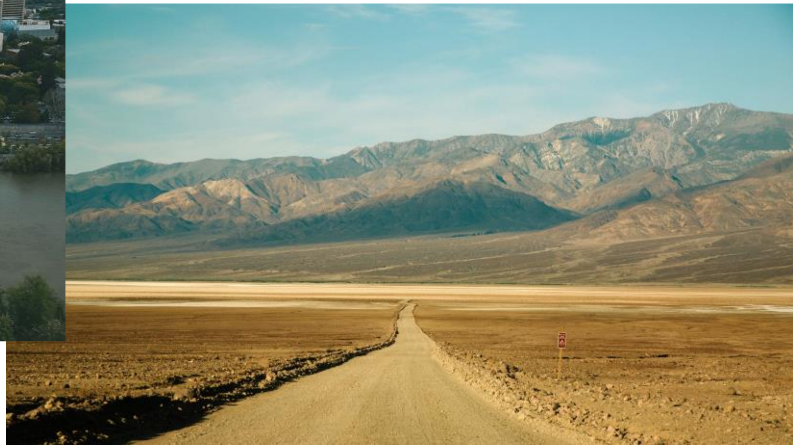
2) Which of the following statements is false?
   - A) *Heat capacity* is the quantity of heat required to change the temperature of a given amount of a substance by 1 °C.
   - B) The smaller a substance's *specific heat capacity*, the more energy required to raise its temperature.
   - C) Water has an unusually high *specific heat capacity*.
   - D) Units of *specific heat capacity* are typically J/g·°C
   - E) Water's *specific heat capacity* plays an important role in weather patterns.

We know different materials respond to added heat differently. When boiling water for pasta the metal gets hot very quickly but it takes a lot of heat to make the water boil.

Background: Application of water's high heat capacity

- Due to water's high heat capacity, areas near large bodies of water will tend to have cooler summers and warmer winters than dry/inland locations.

	San Francisco	Sacramento	Death Valley
Warmest monthly average	23 °C	34 °C	46 °C
Coolest monthly average	5 °C	3 °C	3 °C
Average monthly range	8.5 °C	16.5 °C	27.5 °C



Background: Heat Capacity information

Each material has its own characteristic response to adding heat. We call this the *specific heat capacity* (or *specific heat),* C, of a substance.

- Materials with large specific heat capacities resist changes in temperature: You have to put in more heat to cause an increase in their temp and you have to remove more heat to cause a decrease in their temp.
- The formula for calculating specific heat capacity of a substance requires taking the amount of heat we add and dividing it by the mass and the change in temperature.

heat

specific heat capacity

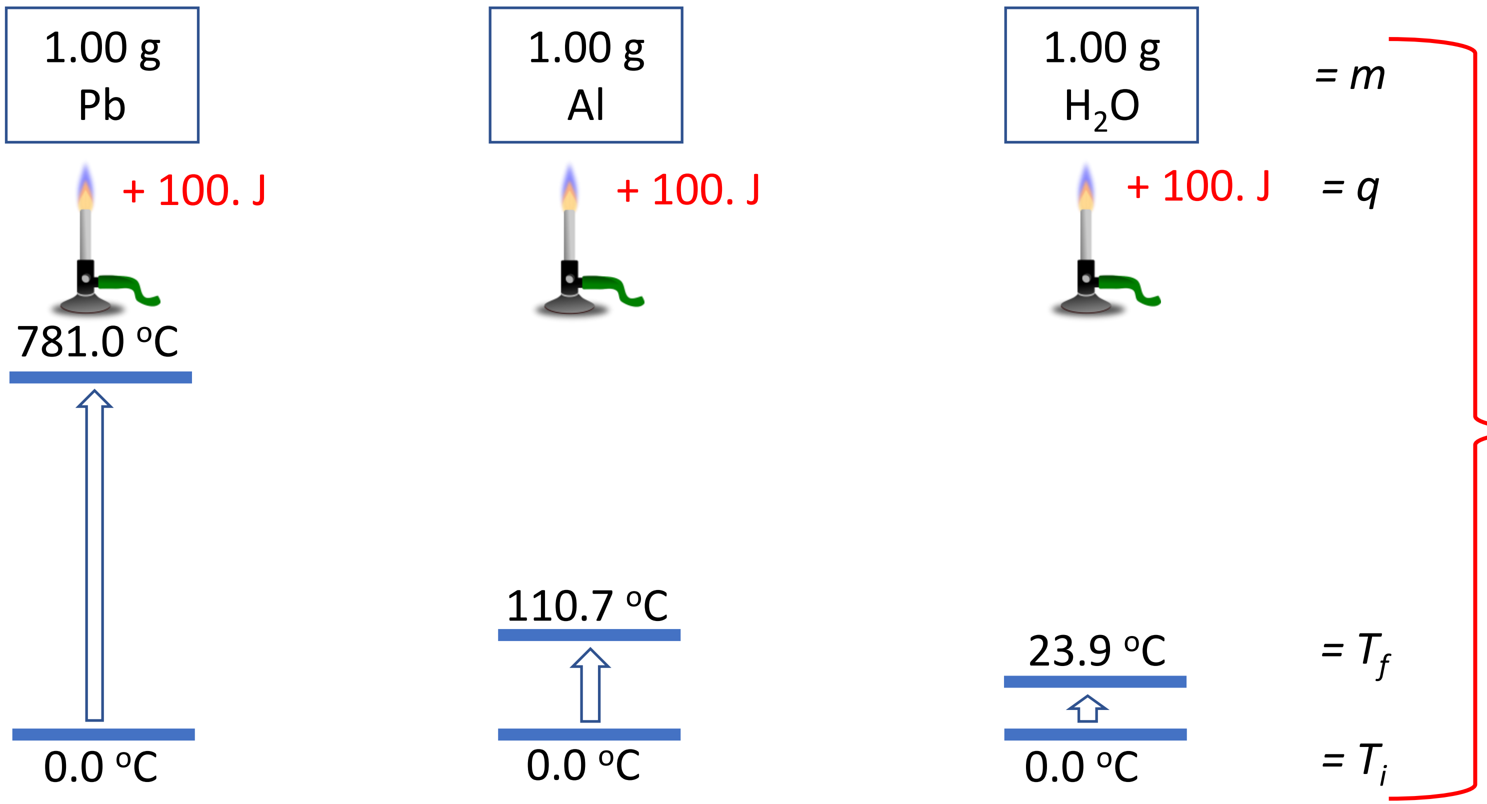
$$C = \frac{q}{m\,\Delta T} = \frac{q}{m\,(T_f - T_i)}$$

mass

temperature change

Background: Determining Specific Heat Capacity

- We have the following three samples. We add the same amount of heat to each and see what happens to their temperatures...



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

$$C_{Pb} = \frac{100.\ \mathrm{J}}{(1.00\ \mathrm{g})(781.0\ ^{o}\mathrm{C} - 0.0\ ^{o}\mathrm{C})} = 0.128\ \frac{\mathrm{J}}{\mathrm{g}\ ^{o}\mathrm{C}}$$

$$C_{Al} = 0.903\ \frac{\mathrm{J}}{\mathrm{g}\ ^{o}\mathrm{C}}$$

$$C_{H2O} = 4.18\ \frac{\mathrm{J}}{\mathrm{g}\ ^{o}\mathrm{C}}$$

Background: Heat Capacity information

- These values can be looked up in a table.
- Unusual units: J/g °C
  - Use the units to guide your calculations. Whatever energy, mass, and temperature units you plug in will have to cancel.
- Can rearrange our equation ($C = q/m\Delta T$) to solve for any variable.
  - For ex., solving for "q" gives: $q = mC\Delta T$
  - *Note:* "$-q$" means heat was released (occurs when temp. drops; i.e. $T_f < T_i$)
  - For ex., solving for "ΔT" gives: $\Delta T = \dfrac{q}{m\,C}$

Substance	Specific Heat Capacity (J/g °C)
Lead	0.128
Gold	0.128
Silver	0.235
Copper	0.385
Iron	0.449
Aluminum	0.903
Ethanol	2.42
Water	4.184

Makes sense… we get a big increase in temp if:

we add a lot of heat

or the mass is small

or the substance has a small heat capacity

Progress clicker question: Performing calculations that use heat capacity

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3) How many kJ are needed to heat 4.50 lb of H_2O from its freezing point to its boiling point?

A) 1.88×10^3 kJ

B) 8.54×10^5 kJ

C) 854.0 kJ

D) 1.88 kJ

E) 854 kJ

F) 1881 kJ

G) 8.540×10^5 kJ

H) 1.881 kJ

See answer worked out on next slide

Useful info:

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

C_{H2O} = 4.184 J/g °C

Freezing point of H_2O is defined as 0.0 °C

Boiling point of H_2O is defined as 100.0 °C

Work shown for previous question

3) How many kJ are needed to heat 4.50 lb of H_2O from its freezing point to its boiling pt.?

Answer:

- *Rearrange equation:* $q = m\,C\,\Delta T$
- *Convert m, C and Δ T to right units to plug into equation. Use units for C (**J/g °C**) to guide you.*
  - $m = (4.50\text{ lb})\left(\frac{453.6\text{ g}}{1\text{ lb}}\right) = \boxed{204}1.2\text{ g}$ *3sf*
  - $C_{H2O} = 4.184\text{ J/g °C}$ *4sf*
  - $\Delta T = T_f - T_i = 100.0\text{ °C} - 0.0\text{ °C} = 100.0\text{ °C}$ *∞ sf*, because these are definitions on the Celsius scale
- *Calculation:*

$$q = m\,C\,\Delta T = (\underset{3sf}{\boxed{204}1.2\,\cancel{g}})(\underset{4sf}{4.184\text{ J}/\cancel{g}\,\cancel{°C}})(\underset{\infty\,sf}{100.0\,\cancel{°C}})$$

We are left with units of "J".

$$= 854038.08\,\cancel{J}\left(\frac{1\text{ kJ}}{10^3\,\cancel{J}}\right) = 854.03808\text{ kJ} = \mathbf{854\text{ kJ}}$$

Keep 3sf

Progress clicker question: Performing calculations that use heat capacity
Go to LearningCatalytics.com Session ID = 88787897

4) A sample of aluminum requires 85 J to heat it from room temperature (72 °F) to 96 °F. What is the mass of the sample of aluminum? [*Remember:* Never work in °F. Convert your temperatures to °C first.]

A) 7.1 g
B) 14 g
C) -21 g
D) 0.14 g
E) 21 g
F) 17 g

Useful info:

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

C_{Al} = 0.903 J/g °C

°C = (°F – 32)/1.8

See answer worked out on next slide

Work shown for previous question

4) A sample of aluminum requires 85 J to heat it from room temperature (72 °F) to 96 °F. What is the mass of the sample of aluminum? [*Remember:* Never work in °F. Convert your temperatures to °C first.]

Answer:

- *Rearrange equation:* $m = \dfrac{q}{c\,\Delta T}$
- *Gather your values with the right units. Use* **J/g ºC** *to guide you.*
  - q = 85 J
  - C_{Al} = 0.903 J/g ºC
  - 72 °F → °C = (72 °F – 32)/1.8 = $\boxed{22}$.222 °C
  - 96 °F → °C = (96 °F – 32)/1.8 = $\boxed{35}$.556 °C
  - $\Delta T = T_f - T_i$ = 35.556 °C – 22.222 °C = $\boxed{13}$.334 ºC

  2sf

- *Calculation:*

$$m = \frac{q}{c\,\Delta T} = \frac{\overset{2sf}{85\ \cancel{J}}}{(\underset{3sf}{0.903}\ \cancel{J}/g\ \cancel{ºC})(\underset{2sf}{\boxed{13}.334}\ \cancel{ºC})} = 7.0|59\ g = \mathbf{7.1\ g}$$

Keep 2sf

Progress clicker question: Performing calculations that use heat capacity
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5) You and some friends are planning a camping trip. One night you plan to make pasta and will be heating 2.0 kg of water from 25°C to its boiling point. If the fuel you are bringing gives off 35 kJ of heat per gram when it is burned, how many grams of fuel should you bring with you?

A) 630 g
B) 2.2×10^4 g
C) 1.8×10^4 g
D) 18 g
E) 6.3×10^2 g
F) 2.2 g

Useful info:

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

$C_{H2O} = 4.184$ J/g °C

Boiling point of H_2O is defined as 100.0 °C

See answer worked out on next slide

Work shown for previous question

5) One night you plan to make pasta and will be heating 2.0 kg of water from 25°C to its boiling point. If the fuel you are bringing gives off 35 kJ of heat per gram when it is burned, how many grams of fuel should you bring with you?

Answer: First determine the amount of heat needed to warm the 2.0 kg of water:

- *Rearrange equation:* $q = m\,C\,\Delta T$
- *Gather your values with the right units. Use* **J/g °C** *to guide you.*
  - $m = 2.0\ \cancel{\text{kg}} \left(\frac{10^3\ \text{g}}{1\ \cancel{\text{kg}}}\right) = \boxed{20}00\ \text{g}$
  - $C_{H2O} = 4.184\ \text{J/g °C}$
  - $\Delta T = T_f - T_i = 100.0\ °\text{C} - 25\ °\text{C} = 75\ °\text{C}$
- *Calculation:* $q = (\boxed{20}00\ \cancel{\text{g}})(4.184\ \text{J}/\cancel{\text{g}}\ \cancel{°\text{C}})(75\ \cancel{°\text{C}}) = \boxed{62}7{,}600\ \text{J}$

$$= (\boxed{62}7{,}000\ \cancel{\text{J}})\left(\frac{1\ \text{kJ}}{10^3\ \cancel{\text{J}}}\right) = \boxed{62}7.6\ \text{kJ}$$

Next determine the amount of fuel needed to produce that much heat:

- *Calculation:* $(\underbrace{\boxed{62}7.6}_{2sf}\ \cancel{\text{kJ}})\left(\frac{1\ \text{g fuel}}{\underbrace{35}_{2sf}\ \cancel{\text{kJ}}}\right) = \underbrace{17|.9314}_{\text{Keep 2sf}}$ g of fuel = **18 g of fuel**