Name↑ **Thermal Physics** **FINAL** BOOK CHECKLIST 2017

- ☐ Cover page – *Thermal Physics, Shining Mountain Waldorf School, January/February 2017, Your Name* (cardstock!)
- ⬡ [OPTIONAL] Table of Contents
- ☐ Fire & Ice Poem -OR- Other Creative Work
  Title of Poem / Song, Words (using heat terms emotionally / metaphorically)*, Author's Name,* all presented artistically
- ☐ Fire & Ice Demonstration #1 – Steel ball
  Labeled Drawing, Procedure, Observations, Discussion
- ☐ Fire & Ice Demonstration #2 – Test tube
  Labeled Drawing, Procedure, Observations, Discussion
- ☐ Inverted Flask Demonstration
  Labeled Drawing, Procedure, Observations, Discussion
- ⬡ [SUGGESTED] Thermal Physics Phenomena Explained
  (Suggested Drawing), Concise Explanation of Phenomena
- ⬡ [CONSIDER] Dewar Flask
- ☐ Thermometer Calibration Lab
  (Optional Drawing), Equipment List, Procedure, Thermometer Tracing, Calculations (2), Discussion
- ☐ Mixing Hot and Cold Water Lab
  Labeled Drawing, (Equipment List), Procedure, Data Table, Calculations (4), Discussion
- ☐ Specific Heat Lab
  (Optional Drawing), Equipment List, Procedure, Data Table, Calculations (5), Discussion
- ☐ Latent Heat Lab
  Labeled Drawing, (Equipment List), Procedure, Data Table & Graph, Observations, Discussion
- ⬡ [CONSIDER] Heat: Transference and Effects
  Transfer (3), Visible Emission, Expansion, Phases (4), P-V-T
- ⬡ [CONSIDER] The Merriconeag Problem
  Equations, Thermodynamic Properties of Ammonia, The Question, Calculations, The Answer (all on one page)
- ⬡ [CONSIDER] Essay – Is there more to the world (and us) than we can measure?

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DEMOS FROM *THERMAL PHYSICS PHENOMENA EXPLAINED* PAGE:
Four Balls – Holding tennis, juggling, large aluminum, 1" steel ball
Three Buckets – Hands in hot and ice water, then both in warm water
Candle – Sensing warmth with hand held beside vs. held above
Ball & Ring – Heating metal ball and attempting to pass through ring
Ceiling and Floor – Sensing warmth with hand held high vs. low
Food Dye – Color shows water moving in loop with corner heated
Magic Spatula – Bimetal band bending when heated
Floating Globes – Temperature affecting how many globes float
Magic Fountain – Water rushing into previously steam-filled flask
Crushing Cans – Cans heated, filled with steam, sealed, crushed
Exhaling – Exhaling gently into hand with wide mouth vs. pursed lips
Twin Cans #1 – Black / silver cans of water warmed in sunlight
Twin Cans #2 – Black / silver cans of hot water cooling on counter
Propane Tank & Adapter – Metal gets cold when propane released
Radioscope – Black/white vanes move when placed in sunlight
Fire Piston – Flash of flame from cotton when air compressed

General Reminders… DON'T PLAGIARIZE! (Ask if unsure.)

- ★Lab partner? Borrowed notes? Acknowledge it! Either in an *acknowledgments* section, or on a dedicated page.
- The following *must* be done by hand...
  - Main titles for pages / drawings / diagrams / graphs
  - Page borders (½" minimum from the left side)
  - The entire poem page & the entire cover page
- Be mindful to keep logical separation between *procedures, observations*, and *discussions*. (Except for the Thermal Physics Phenomena Explained page.)
- *Calculations* sections should carefully show every step in the process, starting with a formula (if there is one). They should be readable. Give more than just answers.
- In general, ink or colored pencil is preferable to plain graphite. Shading or coloring of drawings is helpful.
- Wise use of color (title, diagram, borders, calculations) can greatly improve the look and readability of a page.
- Be consistent in the overall design of your book.
- Creative and artistic elements are nice, but the conceptual content of the book is what matters most. ☺

THE MERRICONEAG PROBLEM

Equations

Temperature change within a phase: $Q = m \cdot c \cdot \Delta T$

Change of phase at given temperature: $Q = m \cdot h$

Thermodynamic Properties of Ammonia

Specific Heat Capacity:	c_{solid}	→	0.50 cal./g.·°C.
Melting Point:	$T_{melting}$	→	−75° C.
Heat of Fusion:	h_{fusion}	→	±108.1 cal./g.
Specific Heat Capacity:	c_{liquid}	→	1.12 cal./g.·°C
Boiling Point:	$T_{boiling}$	→	−33.4° C.
Heat of Vaporization:	$h_{vaporization}$	→	±327.1 cal./g.
Specific Heat Capacity:	c_{gas}	→	0.52 cal./g.·°C.

The Question

How much heat (in calories) is needed to change 85 g. of −92° C. solid ammonia into 14° C. gas?

Calculations

$Q_1 = m \cdot c_{solid} \cdot (T_{melting} - T_{INITIAL})$

$Q_2 = m \cdot h_{fusion}$

$Q_3 = m \cdot c_{liquid} \cdot (T_{boiling} - T_{melting})$

$Q_4 = m \cdot h_{vaporization}$

$Q_5 = m \cdot c_{gas} \cdot (T_{FINAL} - T_{boiling})$

$Q_{total} = Q_1 + Q_2 + Q_3 + Q_4 + Q_5$ ← The Answer [43769.9 cal.]

solid	Q_2	liquid	Q_4	gas
−92° →	−75° →		−33.4° →	14°
	Q_1 melts	Q_3	boils	Q_5

SOME THINGS TO KNOW...*

**not* a complete list!

Laboratory equipment we used…

Bunsen burner, Ring stand, Ring, Asbestos center, Clay triangle, Tripod, Tongs, Test tube, Beaker, Florence flask, Erlenmeyer flask, Glass tubing, Utility clamp, Rubber stopper, Goggles, Graduated cylinder, Volumetric flask, Thermometer

Physics terms and concepts…

Conduction, Convection, Radiation, Emit, Absorb, Reflect, Expand, Contract, Conductor, Insulator, Opaque, Transparent, Calibrate, Phase, Solid, Liquid, Gas, Mass, Pressure, Volume, Temperature, Specific Heat, Sensible Heat, Latent Heat, Calorie

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Temperature changes within a given phase:

$$Q = m \cdot c \cdot \Delta T$$

Specific heat capacity depends on substance and phase...

$$c_{solid},\ c_{liquid},\ c_{gas}$$

...and is measured in...

$$calories\ /\ (gram \cdot °Celsius)$$

Change of phase at a specific temperature:

$$Q = m \cdot h$$

Heat of phase change depends on substance and transition:

$$h_{fusion},\ h_{vaporization}$$

...and is measured in...

$$calories\ /\ gram$$

In all of the above...

Q	→	heat	→	*calories*
m	→	mass	→	*grams*
T	→	temperature	→	*°Celsius*

...and...

$$\Delta T = T_{final} - T_{initial}$$

HISTORY TO KNOW... Fahrenheit's **four** improvements to Rømer's thermometer, and the reasons each mattered.

TEMPERATURES TO KNOW...

Freezing Point of Water : 0° C. / 32° F.
Boiling Point of Water : 100° C. / 212° F.
Absolute Zero : −273° C. / 0 K