Name: ______________________

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B.1 Thermal Energy Transfers

Understandings

- o Molecular theory in solids, liquids, and gases.
- o Density ρ as given by $\rho = \frac{m}{V}$.
- o Kelvin and Celsius scales are used to express temperature.
- o The change in temperature of a system is the same when expressed with the Kelvin or Celsius scales.
- o The internal energy of a system is the total intermolecular potential energy arising from the forces between the molecules plus the total random kinetic energy of the molecules arising from their random motion.
- o Temperature difference determines the direction of the resultant thermal energy transfer between bodies.
- o A phase change represents a change in particle behavior arising from a change in energy at constant temperature.
- o Quantitative analysis of thermal energy transfers Q with the use of specific heat capacity c and specific latent heat of fusion and vaporization of substances L as given by $Q = mc\Delta T$ and $Q = mL$.
- o Conduction, convection, and thermal radiation are the primary mechanisms for thermal energy transfer.
- o Conduction in terms of the difference in the kinetic energy of particles.
- o Quantitative analysis of rate of thermal energy transfer by conduction in terms of the type of material and cross-sectional area of the material and the temperature gradient as given by $\frac{\Delta Q}{\Delta t} = kA\frac{\Delta T}{\Delta x}$.
- o Qualitative description of thermal energy transferred by convection due to fluid density differences.
- o Quantitative description of thermal energy transferred by convection due to fluid density differences.
- o Quantitative analysis of energy transferred by radiation as a result of the emission of electromagnetic waves from the surface of a body, which in the case of a black body can be modeled by the Stefan-Boltzmann law as given by

$L = \sigma A T^4$ where L is the luminosity, A is the surface area, and T is the absolute temperature of the body.
- The concept of apparent brightness b.
- Luminosity L of a body as given by $b = \frac{L}{4\pi d^2}$.
- The emission spectrum of a black body and the determination of the temperature of the body using Wien's displacement law as given by $\lambda_{\max} T = 2.9 \times 10^{-3}$ mK where $\lambda_{\max}$ is the peak wavelength emitted.

Equations

$$\rho = \frac{m}{V}$$

$$\overline{E_{\mathrm{k}}} = \frac{3}{2} k_{\mathrm{B}} T$$

$$Q = mc\Delta T$$

$$Q = mL$$

$$\frac{\Delta Q}{\Delta t} = kA\frac{\Delta T}{\Delta x}$$

$$L = \sigma A T^4$$

$$b = \frac{L}{4\pi d^2}$$

$$\lambda_{\max} T = 2.898 \times 10^{-3} \text{ mK}$$

If you are interested in learning more about thermal physics then please read the book *Concepts in Thermal Physics* by Stephen J. Blundell and Katherine M. Blundell.

Visiting the coldest town in the world - Chilling Out | 60 Minutes Australia
60 Minutes Australia
https://www.youtube.com/watch?v=l1noUh2NrLI

The hottest place on Earth | 60 Minutes Australia
60 Minutes Australia
https://www.youtube.com/watch?v=bdeOZ6rJ36Q

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Use your favorite sources to answer the following questions

1. Define *solid*. What are its characteristics?

2. Define *fluid.*

3. Define *liquid*. What are its characteristics?

4. Define *gas*. What are its characteristics?

5. Define and give the units for each variable for density $\rho = \frac{m}{V}$. Is it a scalar or vector? Do not confuse density ρ with power P or momentum $\vec{p}$ or pressure p!

6. Define *diffusion.*

7. Which state of matter has the most potential energy: a solid, a liquid, or a gas?

8. Define *temperature.*

9. Define *Degrees Celsius*. What is the melting point and the boiling point of water in *degrees Celsius*?

10. Define *Kelvin*. What is the melting point and the boiling point of water in Kelvin?

11. Define *absolute zero.*

12. Which has greater kinetic energy: 0 °C ice or 0 °C water? Which has greater potential energy?

13. Define and give the units for each variable of the equation for *Boltzmann's constant* $k_{\mathrm{B}} = \frac{R}{N_{\mathrm{A}}}$.

14. Define and give the units for each variable for the equation for the internal energy of an ideal gas $\overline{E_{\mathrm{k}}} = \frac{3}{2} k_{\mathrm{B}} T = \frac{3}{2} \frac{R}{N_{\mathrm{A}}} T$.

15. Define *thermal equilibrium.*

16. Define *heat.*

17. Define *internal energy.*

18. Define *phase change.*

19. What does the equation $Q = mc\Delta T$ tell us? Define and give the units of each variable.

20. Define *melting*. Does an object gain potential energy or lose potential energy when it melts? What about kinetic energy?

21. Define *freezing*. Does an object gain potential energy or lose potential energy when it freezes? What about kinetic energy?

22. Define *vaporization/boiling*. Does an object gain potential energy or lose potential energy when it vaporizes/boils? What about kinetic energy?

23. Define *condensation*. Does an object gain potential energy or lose potential energy when it condenses? What about kinetic energy?

24. What does the equation $Q = mL_{\mathrm{f}}$ tell us? Define and give the units of each variable.

25. What does the equation $Q = mL_{\mathrm{v}}$ tell us? Define and give the units of each variable.

26. Moses has 500 grams of gold.

   a. What is the specific heat capacity of gold in $\frac{\text{J}}{\text{kg}\times{}^{\circ}\text{C}}$?
   http://hyperphysics.phy-astr.gsu.edu/hbase/Tables/sphtt.html

   b. How much energy will it take to increase the temperature of solid gold by 50°C?

   c. How much energy will be lost by solid gold if its temperature decreases by 50°C?

27. How much energy will be needed to increase the temperature of 0.8 kg of solid ice from minus 30°C to steam at plus 140°C? Draw a temperature vs. energy graph of this process.

28. Aaron drops a 6 kg gold block with a temperature of 20°C into a tub with 2 kg of liquid water at 90°C. What will be the final temperature of the system?

29. Define *conduction, convection,* and *radiation.* Give an example of each.

30. What is the difference between a *thermal conductor* and *thermal insulator*? Give an example of each.

31. Describe the equation $\frac{\Delta Q}{\Delta t} = kA\frac{\Delta T}{\Delta x}$.

32. Define *absorb*, *reflect* and *emit.*

33. Define *black body.*

34. State the definition, equation, and units for *emissivity*. What is the *emissivity* of a really dark colored object? What is the *emissivity* of a really light colored object?

35. Define *luminosity L.* Units?

36. What does the *Stefan-Boltzmann law* tell us? State the equation and define each variable in the *Stefan-Boltzmann law*.

37. Define *apparent brightness b*. Units? What is the mathematical relationship between *apparent brightness b* and *luminosity L*?

38. What does *Wien's displacement law* tell us? State the equation and define each variable for *Wien's displacement law*. Draw and label a graph describing *Wien's displacement law*.

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B.2 Greenhouse Effect

Understandings

- The conservation of energy.
- Emissivity as the ratio of the power radiated per unit area by a surface compared to that of an ideal black surface at the same temperature as given by $\text{emissivity} = \frac{\text{power radiated per unit area}}{\sigma T^4}$.
- Albedo as a measure of the average energy reflected off a macroscopic system as given by $\text{albedo} = \frac{\text{total scattered power}}{\text{total incident power}}$.
- The Earth's albedo varies daily and is dependent on cloud formations and latitude.
- The solar constant *S*.
- The incoming radiative power is dependent on the projected surface of a planet along the direction of the path of the rays, resulting in a mean value of the incoming intensity being $\frac{S}{4}$.
- Methane CH_4, water vapor H_2O, carbon dioxide CO_2, and nitrous oxide N_2O are the main greenhouse gases and each of these has origins that are both natural and created by human activity.
- The absorption of infrared radiation by the main greenhouse gases in terms of the molecular energy levels.
- The augmentation of the greenhouse effect due to human activities is known as the enhanced greenhouse effect.

Equations

$$\text{emissivity} = \frac{\text{power radiated per unit area}}{\sigma T^4}$$

$$\text{albedo} = \frac{\text{total scattered power}}{\text{total incident power}}$$

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Use your favorite sources to answer the following questions

1. State the law of conservation of energy.

2. State the definition, equation, and units for *emissivity*. What is the *emissivity* of a really dark colored object? What is the *emissivity* of a really light colored object?

3. State the definition, equation, and units for *albedo*. What is the *albedo* of a really dark colored object? What is the *albedo* of a really light colored object?

4. What is the mathematical relationship between the *albedo* and *emissivity* of an object?

5. What is the meaning, value, and units of the Sun-Earth *solar constant*?

6. Describe the equation $\bar{I} = \frac{P}{A} = \frac{S}{4}$.

7. Define the *greenhouse effect* and the *enhanced greenhouse effect*. What are the four major *greenhouse gases*? State their name and chemical formula.

Part 2: Browse these websites for more information on climate change

The world's most viewed site on global warming and climate change
www.wattsupwiththat.com

Climate Depot: Redefining Global Warming Reporting
https://www.climatedepot.com/

Climate Hustle
https://www.climatehustle.org/

Climate Hustle 2
https://www.climatehustle2.com/

Let's Review 50 Years of Dire Climate Forecasts And What Actually Happened
https://www.zerohedge.com/political/lets-review-50-years-dire-climate-forecasts-and-what-actually-happened

Let's Review 50 Years of Dire Climate Forecasts and What Actually Happened
https://www.thestreet.com/mishtalk/economics/lets-review-50-years-of-dire-climate-forecasts-and-what-actually-happened

Drought Reveals Medieval "Hunger Stones" in European Rivers
https://www.odditycentral.com/news/drought-reveals-medieval-hunger-stones-in-european-rivers.html

Part 3: Browse these websites for more information on renewable energy

Planet of the Humans
https://planetofthehumans.com/

Are EVs Good For The Environment? ...Mostly Not
https://www.zerohedge.com/technology/are-evs-good-environment-mostly-not

The "Battery Fairy" & Other Delusions in the Race to Replace Gas-Powered Cars
https://www.zerohedge.com/energy/battery-fairy-other-delusions-race-replace-gas-powered-cars

Achtung Baby (It's Cold Outside) – Germany's "Green" Energy Fail Rescued By Coal and Gas
https://www.zerohedge.com/technology/achtung-baby-its-cold-outside-germanys-green-energy-fail-rescued-coal-and-gas

"Super Emitters": 1% of People Cause Half of Global Aviation Emissions
https://austrian.economicblogs.org/zerohedge/2020/durden-emitters-global-aviation-emissions/

The 10 Most Insane Requirements of the Green New Deal
https://thefederalist.com/2019/02/07/ten-most-insane-requirements-green-new-deal/

California EV Mandate Could "Lead To Disaster" For State's Already Fragile Electric Grid
https://www.activistpost.com/2020/09/california-ev-mandate-could-lead-to-disaster-for-states-already-fragile-electric-grid.html

The Holy Grail of Endless Energy: Harvesting Blackholes
https://oilprice.com/Energy/Energy-General/The-Holy-Grail-of-Endless-Energy-Harvesting-Blackholes.html

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B.3 Gas Laws

Understandings

- Pressure is given by $P = \frac{F}{A}$ where F is the force exerted perpendicular to the surface.
- The amount of substance n as given by $n = \frac{N}{N_\mathrm{A}}$ where N is the number of molecules and N_A is the Avogadro constant.
- Ideal gases are described in terms of the kinetic energy and constitute a modeled system used to approximate the behavior of real gases.
- The ideal gas law equation can be derived from the empirical gas laws for constant pressure, constant volume, and constant temperature as given by $\frac{PV}{T} = \text{constant}$.
- The equations governing the behavior of ideal gases as given by $PV = nk_\mathrm{B}T$ and $PV = nRT$.
- The change in momentum of particles due to collisions with a given surface gives rise to pressure in gases and, from that analysis, pressure is related to the average translational speed of molecules as given by $P = \frac{1}{3}\rho v^2$.
- The relationship between the internal energy U of an ideal monatomic gas and the number of molecules or amount of substance as given by $U = \frac{3}{2}Nk_\mathrm{B}T$ or $U = \frac{3}{2}RnT$.
- The temperature, pressure, and density conditions under which an ideal gas is a good approximation of a real gas.

Equations

$P = \frac{F}{A}$

$N = \frac{N}{N_\mathrm{A}}$

$\frac{PV}{T} = \text{constant}$

$PV = nRT = Nk_\mathrm{B}T$

$P = \frac{1}{3}\rho v^2$

$U = \frac{3}{2}nRT = \frac{3}{2}Nk_\mathrm{B}T$

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Use your favorite sources to answer the following questions

1. Define and give the units for each variable for *pressure* $P = \frac{F}{A}$. Is it a scalar or vector? Do not confuse pressure P with power P or momentum $\vec{p}$ or density ρ!

2. Define *Avogadro's constant* N_A.

3. Define and give the units for each variable for a *mole* $n = N/N_A$.

4. Define and give the units of *atomic mass unit u.*

5. State some characteristics of an *ideal gas.*

6. What are some differences between an *ideal gas* and a *real gas*?

7. Define and draw a graph showing *Boyle's Law.*

8. Define and draw a graph showing *Charles' Law.*

9. Define and draw a graph showing *Gay-Lussac's Law.*

10. Take *Boyle's Law*, *Charles' Law*, and *Gay-Lussac's Law* to obtain a general equation for an ideal gas.

11. Define and give the units of each variable for the *Ideal Gas Law* $PV = nRT$.

12. Define and give the units of each variable for the *Ideal Gas Law* $PV = Nk_{\mathrm{B}}T$.

13. Define and give the units for each variable for the equation for the kinetic theory of an ideal gas $P = \frac{1}{3}\rho v^2$.

14. Define and give the units for each variable for the equation for the internal energy of an ideal monatomic gas $U = \frac{3}{2}nRT = \frac{3}{2}Nk_{\mathrm{B}}T$.

15. What is the average kinetic energy and speed of $\mathrm{O_2}$ at room temperature 20°C? Assume $\mathrm{O_2}$ is an ideal gas.

16. What is the molar mass of H_2O?

17. How many moles are in 50 grams of H_2O?

18. How many grams are in 20 moles of H_2O?

19. What is the number of moles of an ideal gas in 80 cm^3 at room temperature of 20°C and a pressure of 10^5 Pa?

20. Three moles of an ideal gas originally occupies a volume of 120 cm^3 with a pressure of 10^5 Pa at a temperature of 23°C. What will be its new volume if its pressure is held constant and its temperature increases to 35°C?

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B.4 Thermodynamics

Additional HL Understandings

- The first law of thermodynamics, as given by $Q = \Delta U + W$, results from the application of conservation of energy to a closed system and relates the internal energy of a system to the transfer of energy as heat and as work.
- The work done by or on a closed system as given by $W = P\Delta V$ when its boundaries are changed can be described in terms of pressure and changes of volume of the system.
- The change in internal energy, as given by $\Delta U = \frac{3}{2}nR\Delta T = \frac{3}{2}Nk_{\text{B}}\Delta T$, of a system is related to the change of its temperature.
- Entropy S is a thermodynamic quantity that relates to the degree of disorder of the particles in a system.
- Entropy can be determined in terms of macroscopic quantities such as thermal energy and temperature as given as $\Delta S = \frac{\Delta Q}{T}$ and also in terms of the properties of individual particles of the system as given by $S = k_{\text{B}} \ln \Omega$ where k_B is the Boltzmann constant and Ω is the number of possible microstates of the system.
- The second law of thermodynamics refers to the change in entropy of an isolated system and sets constraints on possible physical processes and on the overall evolution of the system.
- Processes in real isolated systems are almost always irreversible and consequently the entropy of a real isolated system always increases.
- The entropy of a non-isolated system can decrease locally, but this is compromised by an equal or greater increase of the entropy of the surroundings.
- Isovolumetric, isobaric, isothermal, and adiabatic processes are obtained by keeping one variable fixed.
- Adiabatic processes in monatomic ideal gases can be modeled by the equation as given by $PV^{\frac{5}{3}} = \text{constant}$.
- Cyclic gas processes are used to run heat engines.
- A heat engine can respond to different cycles and is characterized by its efficiency as given by $\eta = \frac{\text{useful work}}{\text{input energy}}$.

- The Carnot cycle sets a limit for the efficiency of a heat engine at the temperatures of its heat reservoirs as given by $\eta_{\text{carnot}} = 1 - \frac{T_{\text{c}}}{T_{\text{h}}}$.

Additional HL Equations

$Q = \Delta U + W$

$W = P\Delta V$

$\Delta U = \frac{3}{2}nR\Delta T = \frac{3}{2}Nk_{\text{B}}\Delta T$

$\Delta S = \frac{\Delta Q}{T}$

$S = k_{\text{B}} \ln \Omega$

$PV^{\frac{5}{3}} = \text{constant}$

$\eta = \frac{\text{useful work}}{\text{input energy}}$

$\eta_{\text{carnot}} = 1 - \frac{T_{\text{c}}}{T_{\text{h}}}$

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Use your favorite sources to answer the following questions

1. Define *thermodynamics.*

2. Define a *closed system*.

3. Define an *isolated system*.

4. State the *first law of thermodynamics.*

5. Consider a system filled with an ideal gas and the equation for the law of conservation of energy $Q = \Delta U + W$.

   a. Define ΔU. What is the meaning if $\Delta U > 0$ Joules? $\Delta U = 0$ Joules? $\Delta U < 0$ Joules?

b. Define W. What is the meaning if $W > 0$ Joules? $W = 0$ Joules? $W < 0$ Joules?

c. Define Q. What is the meaning if $Q > 0$ Joules? $Q = 0$ Joules? $Q < 0$ Joules?

6. Describe the equation $W = P\Delta V$.

7. Describe the equation $\Delta U = \frac{3}{2} N k_{\mathrm{B}} \Delta T = \frac{3}{2} n R \Delta T$.

8. Define *thermal equilibrium.*

9. State the *zeroth law of thermodynamics.*

10. What does the area under a *pressure-volume curve* tell us?

    a. Define *isothermal process.* Draw three *isothermal processes (isotherms)* on a *pressure vs. volume* graph.

b. Define *isobaric process*. Draw an *isobaric process* on a *pressure vs. volume graph*.

c. Define *isochoric/isovolumetric process*. Draw an *isochoric/isovolumetric* process on a *pressure vs. volume* diagram.

d. Define *adiabatic process*. Draw an *adiabatic process* on a *pressure vs. volume* graph.

11. Define *entropy* S. Units?

12. Describe the equation $\Delta S = \frac{\Delta Q}{T}$.

13. The change in entropy S of a system is defined as $\Delta S = \frac{\Delta Q}{T}$.
    a. What can we do to make ΔS positive?

    b. What can we do to make ΔS negative?

14. Describe the equation $S = k_{\mathrm{B}} \ln \Omega$.

15. State the *second law of thermodynamics.*

16. State the *Clausius version* of the *second law of thermodynamics.*

17. State the *Kelvin version* of the *second law of thermodynamics.*

18. State the *arrow of time* and *entropy* in terms of the *second law of thermodynamics*.

19. State the *third law of thermodynamics.*

20. Describe the equation $PV^{\frac{5}{3}} = \text{constant}$.

21. Define *heat engine* and *heat pump.*

22. **Use a pencil!** Carefully and clearly draw the *Carnot cycle*. Label the vertical axis and the horizontal axis. Label the adiabatic processes and isothermal processes.

23. In general the efficiency of an engine is $\eta = \frac{\text{useful work}}{\text{input energy}}$. For a *Carnot engine* $\eta_{\text{carnot}} = 1 - \frac{T_{\text{cold}}}{T_{\text{hot}}}$.

   a. Is the *Carnot cycle* a fast or slow process?

   b. Is the *Carnot cycle* realistic?

   c. Is the *Carnot cycle* efficient?

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B.5 Current and Circuits

Understandings

- Cells provide a source of emf.
- Chemical cells and solar cells as the energy source in circuits.
- Circuit diagrams represent the arrangement of components in a circuit.
- Direct current (dc) I as a flow of charge carriers as given by $I = \frac{\Delta q}{\Delta t}$.
- The electric potential difference V is the work done per unit charge on moving a positive charge between two points along the path of the current as given by $V = \frac{W}{q}$.
- The properties of electrical conductors and insulators in terms of mobility or charge carriers.
- Electric resistance and its origin.
- Electrical resistance R as given by $R = \frac{V}{I}$.
- Resistance as given by $\rho = \frac{RA}{L}$.
- Ohm's law.
- The ohmic and non-ohmic behavior of electrical conductors, including the heating effect of resistors.
- Electrical power P dissipated by a resistor as given by $P = IV = I^2R = \frac{V^2}{R}$.
- The combinations of resistors in series and parallel circuits.

Series circuits	Parallel circuits
$I = I_1 = I_2 = \cdots$	$I = I_1 + I_2 + \cdots$
$V = V_1 + V_2 + \cdots$	$V = V_1 = V_2 = \cdots$
$R_s = R_1 + R_2 + \cdots$	$\frac{1}{R_s} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$

- Electric cells are characterized by their emf ε and internal resistance r as given by $\varepsilon = I(R + r)$.

- Resistors can have variable resistance.

Equations

$I = \frac{\Delta q}{\Delta t}$

$V = \frac{W}{q}$

$R = \frac{V}{I}$

$\rho = \frac{RA}{L}$

$P = IV = I^2R = \frac{V^2}{R}$

Series circuits	Parallel circuits
$I = I_1 = I_2 = \cdots$ $V = V_1 + V_2 + \cdots$ $R_s = R_1 + R_2 + \cdots$	$I = I_1 + I_2 + \cdots$ $V = V_1 = V_2 = \cdots$ $\frac{1}{R_s} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$

$\varepsilon = I(R + r)$

If you are interested in learning more about electricity and magnetism then please read the book *Electricity and Magnetism* by Edward M. Purcell and David J. Morin.

The solutions can be found on the YouTube channel Go Physics Go:

https://www.youtube.com/@gophysicsgo/playlists

Part 1: Use your favorite sources to answer the following questions

1. Define *electric potential difference*. Units?

2. What are the units of *voltage*?

3. **Use a pencil and ruler!** The work done in moving a charge is given by the equation $W = q \times \Delta V$. Draw and label a diagram to describe this equation.

4. What is *charge q*? Units?

5. Define *electric current I* and state its equation and units. Do not confuse *current I* with *impulse* $\vec{J}$!

6. What is the relationship in magnitude and direction between *electron flow* and *current* in a conductor?

7. Define resistance. Give the units of *resistance* Ω.

8. What is the resistance of an ideal wire?

9. Define *resistor*. Do resistors increase or decrease the current in a circuit? Why is it necessary to have a resistor in a circuit?

10. Define *resistivity* ρ. Do not confuse resistivity ρ with density ρ!

11. What is the *resistance* of a non-ideal wire directly proportional to?

12. What is the resistance of a non-ideal wire inversely proportional to?

13. Define *Ohm's Law*. Draw a current vs. voltage graph of a resistor obeying Ohm's law.

14. What does a *thermistor* do? Draw a *resistance vs. temperature* graph of a thermistor.

15. What does a *light-dependent resistor* (LDR) do?

16. What does a *potentiometer* do?

17. Define *non-ohmic*.

18. Give three versions of the equation for *electrical power.*

19. Define *electromotive force emf*. What are its units?

20. Resistors in series have the same ___________.

21. Resistors in parallel have the same ___________.

22. How can we simplify many *resistors in series*?

23. How can we simplify many *resistors in parallel*?

24. What does an *ammeter* do? Draw its symbol. What is a characteristic of an *ideal ammeter*? How/Where do we insert an *ammeter* in a circuit?

25. What does a *voltmeter* do? Draw its symbol. What is a characteristic of an *ideal voltmeter*? How/Where do we insert a *voltmeter* in a circuit?

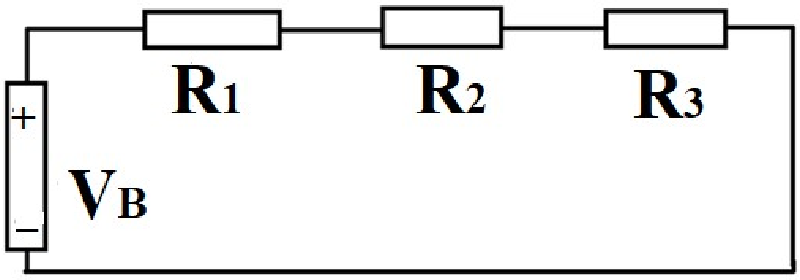
26. What is a *potential/voltage divider*?

27. Define *internal resistance r*. Units?

28. Define the following variables for the equation $\varepsilon = I(R + r)$. Draw an image to describe this equation.

Part 2: Circuits

1. A circuit is shown below:

 	Given: $V_B = 10$ V $R_1 = 2\Omega$ $R_2 = 4\Omega$ $R_3 = 6\Omega$

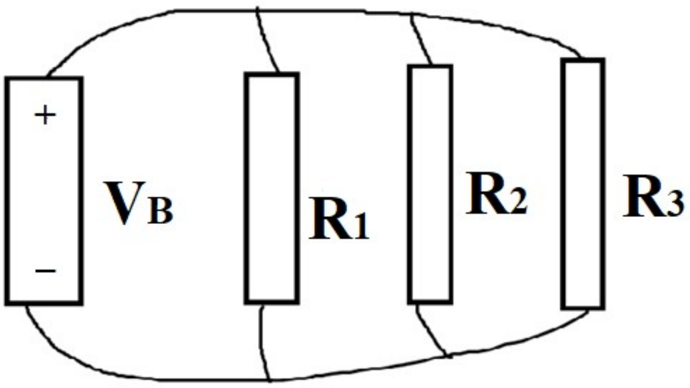
Solve for the unknowns. Fractions only.

$R_{\text{equivalent}} =$ $I_{\text{battery}} =$	$V_1 =$ $V_2 =$ $V_3 =$	$I_1 =$ $I_2 =$ $I_3 =$

What will happen to the current leaving the battery if the number of resistors in series increases? Will the current increase, decrease, or stay the same?

What will happen to the overall resistance of the circuit if the number of resistors in series increases? Will the overall resistance increase, decrease, or stay the same?

2. A circuit is shown below:



Given:

$V_B = 10$ V

$R_1 = 2\ \Omega$

$R_2 = 4\ \Omega$

$R_3 = 6\ \Omega$

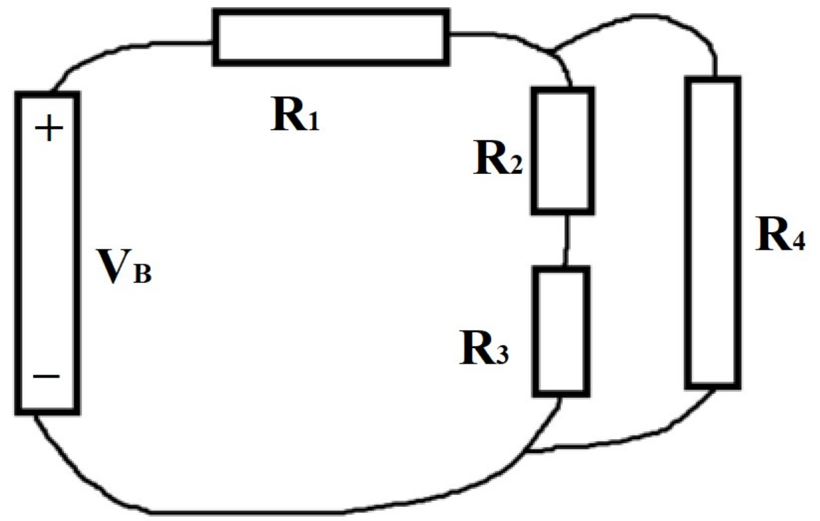
Solve for the unknowns. Fractions only.

$R_{\text{equivalent}} =$ $I_{\text{battery}} =$	$V_1 =$ $V_2 =$ $V_3 =$	$I_1 =$ $I_2 =$ $I_3 =$

What will happen to the current leaving the battery if the number of resistors in parallel increases? Will the current increase, decrease, or stay the same?

What will happen to the overall resistance of the circuit if the number of resistors in parallel increases? Will the overall resistance increase, decrease, or stay the same?

3. A circuit is shown below:



Given:

$V_B = 10\ V$

$R_1 = 2\Omega$

$R_2 = 4\Omega$

$R_3 = 6\Omega$

$R_4 = 8\Omega$

Solve for the unknowns. Fractions only.

$R_{\text{equivalent}} =$ $I_{\text{battery}} =$	$V_1 =$ $V_2 =$ $V_3 =$ $V_4 =$	$I_1 =$ $I_2 =$ $I_3 =$ $I_4 =$

4. A cell with internal resistance is connected to a 3 Ω resistor. Determine the internal resistance r of the cell if the current going through it is 2 Amps when its ε is 12 V.

5. A battery with internal resistance is connected to a variable resistor. When the resistor has a resistance R of 12 Ω the current is 2 Amps. When the resistor has a resistance R of 6 Ω the current is 3 Amps. Determine the emf ε and internal resistance r of the battery.