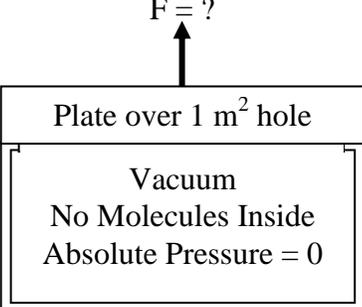


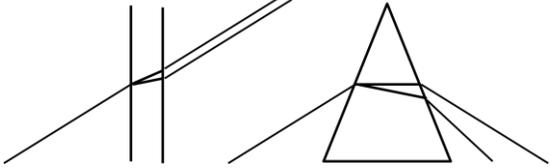
Questions	Answers
1. <b>5 Points:</b> The speed of light is about 186,282 mi/sec. Convert this to km/sec where 1 mi = 1.609344 km and round answer to 3 significant figures.	300,000 km/sec
2. <b>5 Points:</b> Give an example of an un-testable hypothesis. Is such a hypothesis “scientific” or “unscientific?” Explain. Is such a hypothesis a scientifically credible alternative to a scientific theory? Explain.	A secret magical word exists closed to muggles (non-magical folks) entered by passing through Platform 9 ¾. This is unscientific and cannot be tested. It is not a credible alternative to a scientific theory.
3. <b>5 Points:</b> What is the difference between atomic number and nucleon number (mass number)?	Atomic number is the number of protons in the nucleus and the number of positive charges. This is the most important number to chemistry and in a neutral atom is the same as the number of electrons. The nucleon number counts both protons and neutrons and is close to, but not exactly, the mass of an isotope in AMU. For this reason it is often called the mass number, but because of this confusion the preferred modern parlance is nucleon number.
4. <b>5 Points:</b> What is the main difference between the atoms of two isotopes of the same element (for example, ${}_1\text{H}^1$ and ${}_1\text{H}^3$ ), and two different elements (for example, ${}_1\text{H}^3$ and ${}_2\text{He}^3$ )? Hint: The superscript tells you the nucleon number (how many nucleons, protons and neutrons, it contains) and the subscript is the atomic number.	Two isotopes of the same element have different mass, but the same nuclear charge and are nearly identical chemically. Even if the same nucleon number, if the atomic number is different then they atoms behave much different chemically.
5. <b>5 points:</b> What element is chemically most like Calcium (Ca)? Consult periodic table. BTW, this property is very useful in medicine. (a) Aluminum (Al) (b) Barium (Ba) (c) Potassium (K) (d) All of the above (e) None of the above	Ba as it is also a column 2 element.
6. <b>5 Points:</b> If an 80 kg halfback is tackled by a 105 kg lineman, which one exerts the larger force on the other? Which physics principle applies? Explain.	They exert the same force on each other according to Newton’s third law and conservation of momentum.
7. <b>10 Points:</b> A student drives 87 km home for Christmas. She travels part way home at 92 km/hr for 49 min. (a) What distance was traveled during the first portion of her trip? (b) It takes an additional 15.5 min. to complete the trip due to heavy traffic. What is the average speed (in km/hr) during this leg of the trip? (c) What is the average speed (in km/hr) for the total trip?	(a) 75.1 km. (b) 45.9 km/hr. (c) 80.9 km/hr

Questions	Answers
<p>8. <u>10 Points:</u> An ice cube has a mass of 41 gm (1000 gm = 1 kg) and is floating in a glass of water.</p> <p>(a) How much does it weigh in Newtons? Recall acceleration of gravity, <math>g</math>, is <math>9.8 \text{ m/sec}^2</math> on Earth.</p> <p>(b) What is the buoyant force in Newtons? Hint: The force keeping the ice cube floating.</p> <p>(c) What is the net force in Newtons acting on the ice cube?</p> <p>(d) Moon's gravity is about 1/6 of Earth. What is the ice cube's mass in gm on the Moon?</p> <p>(e) How much does it weigh in Newtons on the Moon?</p> <p>(f) What is the buoyant force in Newtons on the Moon?</p> <p>(g) What is the net force in Newtons acting on the ice cube on the Moon?</p> <p>(h) Will it still float in water on the Moon?</p>	<p>(a) -0.402 N (upward forces are positive).  (b) 0.402 N. (c) zero. (d) 41 gm. (e) -0.670 N.  (f) 0.670 N. (g) zero. (h) yes.</p>
<p>9. <u>5 Points:</u> Iodine 131 (<math>{}_{53}\text{I}^{131}</math>) is important for a couple reasons. It is a common gaseous byproduct of nuclear power production which, if released to the atmosphere, would be deleterious. However encapsulated it is useful to treat cancer. In this isotope:</p> <p>(a) What is the atomic number?</p> <p>(b) What is the nucleon number?</p> <p>(c) What is the number of protons?</p> <p>(d) What is the number of neutrons?</p>	<p>(a) <math>Z = 53</math>. (b) Nucleons = 131. (c) Protons = <math>Z = 53</math>.  (d) Neutrons = <math>131 - 53 = 78</math>.  Note: The modern preferred wording is nucleon number. In the past it was referred to as mass number since it's close, but not exactly equal to, the mass in AMU units. Because it's not exactly equal to mass there was confusion so in modern parlance we call it the nucleon number, that is, the sum of proton and neutron (particles in the nucleus).</p>
<p>10. <u>5 Points:</u> Name an element that is chemically similar to Sodium (Na).</p>	<p>Anything in the first column. Li, K, Rb, Cs, or Fr.  Anything in the same column is chemically similar.</p>
<p>11. <u>10 Points:</u> Superman's mass is 101 kg and has a velocity of 54 m/sec in the x direction. And Supergirl's mass is 54 kg and has a velocity of 101 m/sec in the negative x direction. They collide head on.</p> <p>(a) What is Superman's original momentum?</p> <p>(b) What is Supergirl's original momentum?</p> <p>(c) What is the total original momentum?</p> <p>(d) What is the total momentum after collision?</p> <p>(e) Who exerts more force on the other? Does Superman exert more force on Supergirl? Does she exert more force on him? Do they exert the same force on each other?</p>	<p>(a) <math>P_m = 5454 \text{ kg m / sec}</math>. (b) <math>P_g = -5454 \text{ kg m / sec}</math>.  Negative because Supergirl is moving in the negative x direction. (c) zero. (d) Also zero since the total momentum before equals the total momentum after. This is the law of conservation of momentum. (e) They exert the same force on each other according to Newton's third law.</p>
<p>12. <u>5 Points:</u> Explain how conservation of momentum applies to a rocket ship lifting off. Does Newton's third law (for every action there is an equal and opposite reaction) apply?</p>	<p>The momentum of the fuel going out the rocket nozzle is equal and opposite to the momentum of the ship. The ship exerts the same force on the burning fuel as the fuel exerts on the ship. Newton's third law applies.</p>

Questions	Answers
<p>13. <b>10 Points:</b> The speed of a satellite in a perfectly circular orbit around Earth is about 8 km/sec and the escape velocity is about 11.2 km/sec. What shape is the orbit if the speed of the satellite is between these two values?</p> <p>(a) Draw this shape and sketch where Earth would be located.</p> <p>(b) Show the location of the greatest gravitational energy on this sketch?</p> <p>(c) Show the location of the greatest kinetic energy on this sketch?</p> <p>(d) Why doesn't a satellite in this orbit fall to the ground?</p> <p>(e) Even if between these two speeds, satellites might not orbit. Why not? BTW, this is how the Apollo astronauts came home from the Moon.</p>	<p>(a) Elliptical shape – Earth at one focus. (b) Greatest gravitational potential energy further from the Earth. (c) Kinetic energy is greatest closest to the Earth. (d) A satellite “falls” around the Earth. (e) A satellite may have sufficient energy, however if its orbit intersects the Earth it will crash. Apollo astronauts did this intentionally hitting the atmosphere at exactly the angle to controllable land.</p>
<p>14. <b>5 Points:</b> A car gains 50,000 J of energy going down a hill, but only has 40,000 J of kinetic energy when it reaches the bottom.</p> <p>(a) How much energy is wasted?</p> <p>(b) What happens to this energy? Where does it go? What form of energy is it converted to?</p> <p>(c) If an engine speeds the car up to the same speed (on the flat and level) it has at the bottom of the hill in 9.3 sec, what is the engine's power?</p>	<p>(a) 10,000 J. (b) The lost energy eventually turns into heat. (c) <math>50,000 \text{ J} / 9.3 \text{ sec} = 5376 \text{ Watts}</math></p>
<p>15. <b>10 Points:</b> An astronaut lands on a planet that has twice the mass and twice the diameter as Earth.</p> <p>(a) Will she weight more, less, or equal to her weight on the surface of the Earth?</p> <p>(b) By what factor? If less the factor is a fraction, if more then the factor is greater than 1, and if equal the factor equals 1.</p> <p>(c) Will her mass be more, less, or equal to her mass on the surface of the Earth?</p> <p>(d) By what factor?</p>	<p>(a) Less. (b) <math>(2)^*(\frac{1}{4}) = \frac{1}{2}</math>. Multiply be 2 due to doubling mass, the multiply by <math>(\frac{1}{2})^2</math> for twice the diameter. If it were 3 times the diameter you'd multiply by <math>(\frac{1}{3})^2</math>. (c) Same mass. (d) 1.0.</p>
<p>16. <b>10 Points:</b> A shady jeweler sells you a 1 kg gold crown. Before you give him any money though, you take out your handy-dandy beaker and measure the volume to be <math>60 \text{ cm}^3</math>.</p> <p>(a) Your friend, Archimedes, tells you not to buy it. Why? Explain. The density of gold is <math>19.3 \text{ g/cm}^3</math>.</p> <p>(b) What is the buoyant force acting on this crown if lowered into fresh water? Recall the density of water is <math>1 \text{ g/cm}^3</math> and, therefore, the weight of <math>1 \text{ cm}^3</math> of water is 0.0098 N.</p>	<p>(a) Density is only <math>16.7 \text{ gm/cm}^3</math> – it is not gold. (b) buoyant force = 9.8 N.</p>

Questions	Answers
<p>17. <u>10 Points:</u> The barometer reads 76 cm of mercury.</p> <p>(a) If the atmosphere were the same density as mercury, how thick would it be? Explain.</p> <p>(b) In SI units this works out to be 101,300 Pa or 101,300 N/m<sup>2</sup>. If I had a 1 m<sup>2</sup> plate over a vacuum chamber, how much force would be on this plate? See diagram at right. In the famous Magdeburg hemispheres experiment of 1654, those hemispheres had a smaller area than this problem and a team of horses couldn't pull them apart.</p> <div style="text-align: center; margin: 20px 0;">  </div>	<p>(a) 76 cm. (b) 101,300 N.</p>
<p>18. <u>10 Points:</u></p> <p>(a) What effect causes a raw egg to spin slower than a hard boiled egg? Note: Bernoulli's Principle is an approximation that ignores this effect.</p> <p>(b) Name a circumstance where you would observe the Bernoulli effect. Explain what is happening.</p>	<p>(a) Drag. Bernoulli's Principle ignores drag.</p> <p>(b) Blowing between two pieces of paper and the paper attracts. Pressure is reduced in the flowing stream of fluid.</p>
<p>19. <u>5 Points:</u> A refrigerator works by inputting work (<math>W_{in}</math>) to a motor to move heat (<math>H_{in}</math>) from the inside to the outside.</p> <p>(e) Write an expression for heat out (<math>H_{out}</math>).</p> <p>(f) Explain how this tells us we can't use a refrigerator to cool our home. It's not because the refrigerator isn't big enough. It's the same problem as putting our air conditioner in the middle of the living room and turning it on. Why won't that work? Explain.</p>	<p>(a) <math>H_{out} = W_{in} + H_{in}</math>. (b) You remove <math>H_{in}</math> amount of heat, but a greater amount, <math>H_{out}</math> is put back into the room. Running a refrigerator will heat, not cool, a room.</p>
<p>20. <u>5 Points:</u> If I had the best engine in the world, an engine without friction, and I put 1000 J of heat into this engine, why would only a fraction of that heat be converted to work? Typically the theoretically best engines would only give 600 J of work output and, in practice, it would only give 400 J. Explain.</p>	<p>Heat is random, thus, by the second law of thermodynamics some is wasted.</p>

Questions	Answers
<p>21. <b>10 Points:</b></p> <p>(a) Name and give examples of the 3 means that heat is moved.</p> <p>(b) Heat is not moved when we rub our hands together to get warm. Where does heat come from in this case?</p>	<p>(a) Conduction, like heat flowing through a pane of glass. Convection, like heat carried with the water moving from an engine to radiator. Radiation, for example, the sun. (b) Rubbing our hands together does not move heat – it is converting mechanical energy to heat.</p>
<p>22. <b>5 Points:</b> Fill in the blanks. Like charges ____ and unlike charges _____. Like magnetic poles _____, unlike magnetic poles _____.</p>	<p>Repel, attract, repel, attract</p>
<p>23. <b>5 Points:</b> What particle carries electrical charge? If a particular particle carries one type of charge, how do we cause the opposite polarity on objects if we're not moving the particles with the other type of charge?</p>	<p>Electrons carry charge, but when they move out of a material they leave the slow and heavy positive charges behind.</p>
<p>24. <b>5 Points:</b> What causes magnetism? Explain why this creates electromagnets. Why does this same effect cause some materials, like iron, to have a permanent magnetism? Microscopically, how is a permanent magnet like an electromagnet?</p>	<p>Magnetism is caused by moving charges. Running current through a coil makes an electromagnet. However electrons orbiting around nuclei magnetize atoms. If more electron orbit one direction than other the material can have a permanent magnetism. Only a few substances are like this – Fe, Co, Ni, and Gd.</p>
<p>25. <b>5 Points:</b> True or False. You can have a negative charge or a positive charge by itself, but you cannot have a north pole or south pole by itself? Explain. You can have a negative charge or a positive charge by itself, but you cannot have a north pole or south pole by itself. Why is this true? Hint: it has to do with how magnetic fields are created in the first place.</p>	<p>True. If you cut a charged object in half you get two objects of the same charge. But if you cut a magnet in half, each half has both a north and south pole. When a charge, even tiny ones like electrons, move in a circle there are two sides which create both a north and south pole together. You can't have one side without the other and, therefore, you can't have one magnetic pole without the other.</p>
<p>26. <b>5 Points:</b> What happens to a moving electron in a magnetic field?</p>	<p>Its path will curve due to force.</p>
<p>27. <b>10 Points:</b> A physics and music student wants to create a pipe for an organ that resonates at middle C, <math>f = 262</math> Hz. The pipe will resonate at its fundamental frequency (that is lowest frequency – the pipe is half a wavelength long). The speed of sound is 340 m/sec.</p> <p>(a) Knowing the speed of sound and the frequency, how do you find the wavelength?</p> <p>(b) Evaluate the wavelength.</p> <p>(c) What is the period of this wave?</p>	<p>(a) <math>\lambda = v/f</math>. (b) 1.30 m. (c) 0.00382 m</p>
<p>28. <b>5 Points:</b> Describe constructive and destruction interference. Explain why the CD disc produces a central spot plus side spots.</p>	<p>Constructive interference is when waves combine to make their crests larger. Destructive interference is when waves combine to counteract each other. The central spot is from ordinary reflection. The side spots are a result of fine lines on the CD (1.6 <math>\mu\text{m}</math> on a CD, 0.75 <math>\mu\text{m}</math> on a DVD) causing constructive interference.</p>

Questions	Answers
<p>29. <u>5 Points:</u> Explain the difference between a transverse and longitudinal wave and give examples.</p>	<p>For a longitudinal wave the displacement is along the direction of the wave, for example, a sound wave. For a transverse wave the displacement is perpendicular to the direction the wave travels.</p>
<p>30. <u>5 Points:</u> Explain the Doppler effect. We know the sound pitch is higher when the sound source (police car for example) is coming toward you and the pitch is lower when the sound source is moving away. This is also true for light. The color of the light from distant objects shifts because they are moving away from us. Explain how the light frequency and wavelengths of these distant galaxies change when they move away. Which way does the color shift for these distant galaxies?</p>	<p>As the police car moves toward you, you hear the crests of the waves more frequently, thus raising the pitch. As it moves away you hear the crests of waves less frequently, thus the pitch drops. As galaxies move away the frequency shifts to lower frequencies, which corresponds to higher wavelengths. Elongating wavelengths shifts light to be more red. The effect is called a red shift.</p>
<p>31. <u>5 Points:</u> Fill in the blanks. Like charges ____ and unlike charges _____. Like magnetic poles ____ and unlike magnetic poles _____.</p>	<p>Repel, attract, repel, attract.</p>
<p>32. <u>10 Points:</u> A physics and music student wants to create a pipe for an organ that resonates at a fifth above middle C, <math>f = 392</math> Hz. The pipe will resonate at its fundamental frequency (that is lowest frequency – the pipe is half a wavelength long). The speed of sound is 340 m/sec.</p> <p>(a) Knowing the speed of sound and the frequency, how do you find the wavelength?</p> <p>(b) Evaluate the wavelength.</p> <p>(c) What is the period of this wave?</p>	<p>(a) <math>\lambda = v/f</math>. (b) 0.867 m. (c) 0.00254 m</p>
<p>33. <u>5 Points:</u> Light has a different index of refraction going through some materials depending on its color. This can make a rainbow, however you didn't see a rainbow in lab. This is due to the fact that the surfaces of the glass were parallel to each other. To make a rainbow, you need a prism. Why? Using principles of refraction (and that different colors refract at different angles) sketch and/or explain why glass must be in the shape of a prism, for example a triangular prism, to create a rainbow.</p>	<p>This is best shown with diagrams. For parallel surfaces, like a pane of glass, the light of different colors emerges parallel. For a prism the light of different colors diverges.</p> 
<p>34. <u>5 Points:</u> What are the three laws of reflection? What is the underlying principle? When young kittens see a mirror they think there is another cat behind the mirror and it looks so real the kitten will begin fighting with the other cat. If the kitten is 10 cm from the mirror, how far away will the kitten's image be?</p>	<p>(1) the angle of incidence equals the angle of reflection, (2) the distance from the object to the mirror is the same as the distance from the image to the mirror, and (3) the line from object to image intersects the mirror at a right angle. There follow from the shortest path principle – that a light ray follows the shortest path from object to observer. The kitten will see its own image 10 cm behind the mirror.</p>

Questions	Answers
<p>35. <b>10 Points:</b> Complete the following nuclear reaction. What element goes in the blank?</p> ${}_{38}\text{Sr}^{90} \rightarrow \underline{\hspace{2cm}} + {}_{-1}\text{e}^0$	${}_{39}\text{Y}^{90}$
<p>36. <b>10 Points:</b> The half life of <math>{}_{38}\text{Sr}^{90}</math> 28.8 yr. If you start with 1 kg how much will you have left after the following:</p> <p>(a) 28.8 yr (one half life)?  (b) 57.6 yr (2 half lives)?  (c) 86.4 yr (3 half lives)?</p>	<p>(a) 0.5 kg. (b) 0.25 kg. (c) 0.125 kg.</p>
<p>37. <b>10 Points:</b> A diode laser emits 670 nm light. Answer the following. Recall <math>1 \text{ nm} = 10^{-9} \text{ m}</math>; <math>h = \text{Plank's constant} = 6.63 \cdot 10^{-34} \text{ J sec}</math>; and <math>c = \text{speed of light} = 3 \cdot 10^8 \text{ m/sec}</math>.</p> <p>(a) What is frequency?  (b) What is the photon energy?</p>	<p>(a) <math>4.48 \cdot 10^{14} \text{ Hz}</math>. (b) <math>2.97 \cdot 10^{-19} \text{ J}</math>.</p>
<p>38. <b>5 Points:</b> Electrons may be accelerated very near the speed of light using easily obtainable voltages (100 kV for example). Electron microscopes can use such electrons to take pictures of atoms (spacing about <math>3 \cdot 10^{-10} \text{ m}</math>). Ignoring relativistic effects, find the wavelength of an electron (<math>m_e = 9.11 \cdot 10^{-31} \text{ kg}</math>) whose speed is <math>1.9 \cdot 10^8 \text{ m/sec}</math>. Recall <math>h = 6.63 \cdot 10^{-34} \text{ J sec}</math>.</p>	$\lambda = h/mv = 3.83 \cdot 10^{-12} \text{ m}$ .
<p>39. <b>5 Points:</b> What is the missing particle in the nuclear decay of:</p> ${}_{6}\text{C}^{14} \rightarrow {}_{-1}\text{e}^0 + \underline{\hspace{2cm}}$	${}_{7}\text{N}^{14}$
<p>40. <b>5 Points:</b> What is the missing particle in the nuclear decay of:</p> ${}_{84}\text{Po}^{210} \rightarrow {}_{2}\text{He}^4 + \underline{\hspace{2cm}}$	${}_{82}\text{Pb}^{206}$