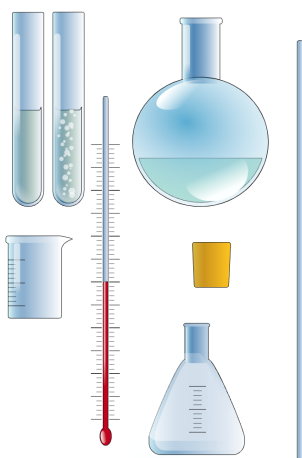




UNIVERSITY INTERSCHOLASTIC LEAGUE

Science

District • 2024



GENERAL DIRECTIONS:

- **DO NOT OPEN EXAM UNTIL TOLD TO DO SO.**
- Contestants may take up to two hours to complete the contest. If you are in the process of actually writing an answer when the signal to stop is given, you may finish writing that answer.
- Papers may not be turned in until 30 minutes have elapsed. If you finish the test in less than 30 minutes, remain at your seat and retain your paper until told to do otherwise. You may use this time to check your answers.
- All answers must be written on the answer sheet provided. Indicate your answers in the appropriate blanks provided on the answer sheet. Write clearly and legibly!
- You may place as many notations as you desire anywhere on the test paper but not on the answer sheet, which is reserved for answers only.
- You may use additional scratch paper provided by the contest director.
- All questions have ONE and only ONE correct (BEST) answer. There is a penalty for all incorrect answers.
- If a question is omitted, no points are given or subtracted.
- The back two pages of this test include a copy of the periodic table of the elements, as well as listings of other scientific relationships. You may use this information during the contest and may detach the back page from the test if you wish.
- A simple scientific calculator is sufficient for the high school Science contest. **The UIL provides a list of approved calculators that meet the criteria for use in the Science contest. No other calculators are permitted during the contest.** The Science Contest Approved Calculator List is available in the current Science Contest Handbook and on the UIL website. Contest directors will perform a brief visual inspection to confirm that all contestants are using only approved calculators. Each contestant may use up to two approved calculators during the contest.

- B01. Which of the following statements is true for lysogeny?
- Lysogeny is a part of mitosis.
 - Lysogeny only occurs in eukaryotic cells.
 - The lysogenic cycle bursts the host cell without delay.
 - Lysogenic viruses use lysogeny to incorporate viral genome into host cell genome.
 - Lysogeny produces two identical cells.
- B02. Acetylcholine is to _____ as estrogen is to ____.
- nervous system; endocrine system
 - muscle; reproductive system
 - nerve fiber; pancreas
 - digestive system; respiratory system
 - integumentary system; reproductive system
- B03. The member of *Enterobacteriaceae* that causes Typhoid fever is
- Klebsiella pneumoniae*.
 - Escherichia coli*.
 - Shigella dysenteriae*.
 - Proteus vulgaris*.
 - Salmonella enterica*.
- B04. An organic macromolecule that contains a chain of C—C with C—H would best be classified into which major macromolecular group?
- lipids
 - carbohydrates
 - amino acids
 - nucleic acids
 - proteins
- B05. Humans, birds, lions, fish, and snakes all belong to
- Domain Eukarya.
 - Supergroup Opisthokonta.
 - Kingdom Animalia.
 - Phylum Chordata.
 - All of the above.
- B06. In a population at Hardy-Weinberg equilibrium, 330 organisms out of 1000 express the recessive phenotype. What is the frequency of the dominant allele?
- 0.181
 - 0.330
 - 0.425
 - 0.574
 - 0.670
- B07. Proteins designated for export from a eukaryotic cell are modified and packaged in the
- nucleus.
 - peroxisome.
 - Golgi apparatus.
 - lysosome.
 - mitochondrion.
- B08. Which of the following is not an example of macroevolution?
- Elephant tusks evolving from canine teeth.
 - Resistance to antibiotics evolving in bacteria.
 - Insect wings evolving from limbs.
 - Feathers evolving from reptile scales.
 - New organs evolving from existing structures.
- B09. If yellow (Y) is dominant over green (y) seeds and round (R) is dominant over wrinkled (r) seeds, what is the probability that seeds from the following cross would be both green and wrinkled s?
- YyRr x YyRr
- 1/32
 - 1/16
 - 3/16
 - 9/16
 - 13/16

- B10. The type of epithelial cells found within the bladder that specifically function to slide across each other as the bladder fills and expands are called
- A) cuboidal cells.
 - B) squamous cells.
 - C) transitional cells.
 - D) basal cells.
 - E) columnar cells.
- B11. Which of the following is not an example of unity in diversity?
- A) Characteristics of all mammals.
 - B) Insect wings and bird wings.
 - C) All organisms are made of cells.
 - D) The forelimbs of bats, humans, whales, and cats.
 - E) Ribosomes, cytosol, DNA, and plasma membranes as structures found in all cell types.
- B12. Land plants belong to Supergroup
- A) Opisthokonta.
 - B) Excavata.
 - C) Amoebozoa.
 - D) Rhizaria.
 - E) Archaeplastida.
- B13. Per glucose, how many NADH are generated in aerobic respiration starting from glycolysis and ending after the Krebs cycle?
- A) 2
 - B) 4
 - C) 6
 - D) 8
 - E) 10
- B14. In January 2024, the Centers for Disease Control and Prevention issued a Food Safety Alert for the outbreak of _____, linked to charcuterie meats.
- A) *Salmonella* sp.
 - B) MRSA
 - C) *Pseudomonas aeruginosa*
 - D) *Escherichia coli*.
 - E) *Mycobacterium tuberculosis*
- B15. When a disease, such as Spanish flu, the plague, COVID, etc. is present across the entire planet at the same time, this is called a/an
- A) transdemic.
 - B) epidemic.
 - C) pandemic.
 - D) endemic.
 - E) none of the above.
- B16. The enzyme that catalyzes the carboxylation of ribulose-1,5-bisphosphate below during photosynthesis is
- A) primase.
 - B) RuBisCO.
 - C) Phosphoglycerate kinase.
 - D) NaBisCO.
 - E) Glyceraldehyde-3-phosphate dehydrogenase.
- B17. Primase, used in DNA replication, is a/an
- A) RNA-dependent RNA polymerase.
 - B) RNA-dependent DNA polymerase.
 - C) DNA-dependent DNA polymerase.
 - D) DNA-dependent RNA polymerase.
 - E) none of the above.
- B18. Given the following DNA *template* strand, what is the RNA sequence after transcription?
- 3'-GTAACATGC-5'
- A) 3'-GUAACAUGC-5'
 - B) 5'-GUAACAUGC-3'
 - C) 3'-CAUUGUACG-5'
 - D) 5'-CAUUGUACG-3'
 - E) 5'-CGUACAAUG-3'

- B19. If an antisense RNA binds to a messenger RNA and overlaps the start codon, the result would most likely be
- A) repression of translation.
 - B) activation of translation.
 - C) repression of transcription.
 - D) activation of transcription.
 - E) export the double-stranded RNA molecules from the cell.
- B20. Which of the following techniques identifies whether a gene is expressed into mRNA?
- A) Western blot
 - B) Southern blot
 - C) CRISPR/Cas9
 - D) Northern blot
 - E) DNA sequencing

- C01. If a helium-filled balloon at STP has a volume of 2.00 L and you add 0.35 grams of helium to the balloon, what will the new volume of the balloon be at STP?



- A) 3.96 L
 B) 0.875 L
 C) 1.96 L
 D) 2.00 L
 E) 22.4 L

- C02. What volume of liquid water would be produced by reacting 15.0 moles of H₂ gas with 15.0 moles of O₂ gas? Assume the density of liquid water is 1.0 gram per milliliter.

- A) 270 mL
 B) 540 mL
 C) 30 mL
 D) 510 mL
 E) 480 mL

- C03. While surfing chemistry websites, you see one that refers to ¹⁶O and ¹⁸O. What is the difference between them?

- A) ¹⁸O has two more electrons than ¹⁶O.
 B) ¹⁸O has two more protons than ¹⁶O.
 C) ¹⁸O has two more neutrons than ¹⁶O.
 D) ¹⁸O is a sample of 18 O atoms and ¹⁶O is a sample of 16 O atoms.
 E) ¹⁸O is 18 moles of oxygen and ¹⁶O is 16 moles of oxygen.

- C04. Which of the compounds below is an ionic compound?

- A) NH₃
 B) H₃PO₄
 C) CH₃NH₂
 D) (NH₄)₃PO₄
 E) These are all covalent compounds

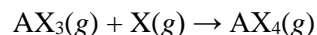
- C05. If the volume of a gas sample is tripled at the same time the number of moles is increased by 50%, what will the final pressure be compared to the initial pressure?

- A) One third
 B) Two thirds
 C) One half
 D) One and one third
 E) One and one half

- C06. Which of these liquids would have the lowest enthalpy of vaporization?

- A) CH₄
 B) CH₃F
 C) CH₃Cl
 D) CH₃F₂
 E) CH₃OH

- C07. Changes in the internal energy of a system show up in the form of heat (*q*) and work (*w*). When the system absorbs energy from the surroundings, the sign on the energy is positive and when the system loses energy to the surroundings the sign on the energy is negative. For this reaction, what are the signs on the heat and work for the system?



- A) *q* = (+) and *w* = (+)
 B) *q* = (+) and *w* = (–)
 C) *q* = (–) and *w* = (–)
 D) *q* = (–) and *w* = (+)
 E) Not enough information is provided.

- C08. What would the freezing point of the solution be if you dissolved 20.0 grams of AlCl₃ in 250 grams of water?

- A) –2.23°C
 B) –1.23°C
 C) 0.00°C
 D) –1.12°C
 E) –4.46°C

- C09. If the following gas-phase reaction is at equilibrium and you increase the temperature, how would the reaction respond?
- $$2\text{SO}_2(g) + \text{O}_2(g) \rightleftharpoons 2\text{SO}_3(g) \quad \Delta H_{\text{rxn}} = -196 \text{ kJ}$$
- A) The equilibrium will shift forward to produce more product
 B) The equilibrium will shift backward to produce more reactants
 C) The reaction will go to completion
 D) The reaction will go backward to completion
 E) The equilibrium concentrations will remain the same but the molecules will be moving faster
- C10. What is the pH of a 3.46×10^{-4} M solution of HClO?
- A) 3.46
 B) 4.46
 C) 5.46
 D) 6.46
 E) 7.46
- C11. Which equation would you use to solve for the molar solubility (x) of iron(II) phosphate if you knew the K_{sp} ?
- A) $K_{\text{sp}} = 4x^3$
 B) $K_{\text{sp}} = 4x^2$
 C) $K_{\text{sp}} = 27x^3$
 D) $K_{\text{sp}} = 27x^4$
 E) $K_{\text{sp}} = 108x^5$
- C12. What is the coefficient on H_2O when the equation for the following redox reaction is balanced in acidic solution using the smallest whole number coefficients?
- $$\text{Sn}(s) + \text{MnO}_4^-(aq) \rightarrow \text{Sn}^{2+}(aq) + \text{Mn}^{2+}(aq)$$
- A) 10
 B) 8
 C) 6
 D) 4
 E) 2
- C13. What happens to the rate constant of a chemical reaction when you increase the temperature of the reaction?
- A) Nothing – rate constants are independent of temperature
 B) Doubling the temperature doubles the rate constant
 C) Doubling the temperature reduces the rate constant by half
 D) The rate constant increases exponentially with temperature
 E) The rate constant decreases exponentially with temperature
- C14. A 100-gram sample of solid CaBr_2 contains
- A) equal masses of calcium and bromine
 B) about twice as many grams of bromine as calcium
 C) about twice as many grams of calcium as bromine
 D) about four times as many grams of bromine as calcium
 E) None of the above answer choices is correct
- C15. Which of these electron transitions in a hydrogen atom will result in the emission of a photon with the shortest wavelength?
- A) $n=4$ to $n=2$
 B) $n=5$ to $n=4$
 C) $n=3$ to $n=2$
 D) $n=6$ to $n=5$
 E) $n=1$ to $n=3$
- C16. In which of these phase changes does the system undergo the largest positive change in entropy?
- A) condensation
 B) vaporization
 C) deposition
 D) sublimation
 E) melting (fusion)

- C17. A chromium atom was walking down a busy tourist boulevard when he suddenly realized one of his electrons was missing! Pickpocketed, perhaps, by a passing non-metal. The police were called, and five of the chromium atom's remaining electrons were questioned as possible witnesses to the crime.

Detectives demanded identification from each of the five electrons, A–E, and each one responded by giving its set of four quantum numbers at the time of the missing electron's disappearance.

- A) $n = 3$ $\ell = 2$ $m_{\ell} = -1$ $m_s = +\frac{1}{2}$
 B) $n = 4$ $\ell = 0$ $m_{\ell} = 0$ $m_s = +\frac{1}{2}$
 C) $n = 3$ $\ell = 1$ $m_{\ell} = 0$ $m_s = -\frac{1}{2}$
 D) $n = 1$ $\ell = 0$ $m_{\ell} = 0$ $m_s = -\frac{1}{2}$
 E) $n = 2$ $\ell = 1$ $m_{\ell} = 1$ $m_s = +\frac{1}{2}$

“Return those four electrons to their subshells,” the chief detective said. “There is only one possible witness to the crime, and it is electron ____!”

Which electron did the detective identify?

- C18. 15.0 mL of a 2.0×10^{-4} M solution of nitric acid is added to a 100 mL volumetric flask and the solution is diluted to the mark with water. What is the pH of the resulting solution?

- A) 2.88
 B) 4.88
 C) 3.70
 D) 7.00
 E) 4.52

- C19. When calcium carbonate is heated it decomposes into calcium oxide and carbon dioxide gas. How many grams of calcium carbonate would be needed to produce 10.0 L of carbon dioxide gas at 1 atm and 25°C ?

- A) 40.93 g
 B) 20.47 g
 C) 44.68 g
 D) 27.84 g
 E) 55.68 g

- C20. Which of these Lewis dot structures for a neutral atom is correct?

- A) $\cdot \ddot{\text{Si}} \cdot$ B) $\cdot \ddot{\text{Se}} \cdot$
 C) $\cdot \ddot{\text{Ar}} \cdot$ D) $\cdot \ddot{\text{P}} \cdot$
 E) $\cdot \ddot{\text{Cl}} \cdot$

Chemistry

										8A 18																									
1A 1												3A 13		4A 14		5A 15		6A 16		7A 17		2													
1	H											5	B	6	C	7	N	8	O	9	F	10	He												
	1.01												10.81		12.01		14.01		16.00		19.00		20.18												
3	Li	4	Be											13	Al	14	Si	15	P	16	S	17	Cl	18	Ar										
	6.94		9.01												26.98		28.09		30.97		32.07		35.45		39.95										
11	Na	12	Mg	3B	4B	5B	6B	7B	8B			1B	2B																						
	22.99		24.31	3	4	5	6	7	8	9	10	11	12																						
19	K	20	Ca	21	Sc	22	Ti	23	V	24	Cr	25	Mn	26	Fe	27	Co	28	Ni	29	Cu	30	Zn	31	Ga	32	Ge	33	As	34	Se	35	Br	36	Kr
	39.10		40.08		44.96		47.87		50.94		52.00		54.94		55.85		58.93		58.69		63.55		65.38		69.72		72.64		74.92		78.96		79.90		83.80
37	Rb	38	Sr	39	Y	40	Zr	41	Nb	42	Mo	43	Tc	44	Ru	45	Rh	46	Pd	47	Ag	48	Cd	49	In	50	Sn	51	Sb	52	Te	53	I	54	Xe
	85.47		87.62		88.91		91.22		92.91		95.94		(98)		101.07		102.91		106.42		107.87		112.41		114.82		118.71		121.76		127.60		126.90		131.29
55	Cs	56	Ba	57	La	72	Hf	73	Ta	74	W	75	Re	76	Os	77	Ir	78	Pt	79	Au	80	Hg	81	Tl	82	Pb	83	Bi	84	Po	85	At	86	Rn
	132.91		137.33		138.9		178.49		180.95		183.84		186.21		190.23		192.22		195.08		196.97		200.59		204.38		207.20		208.98		(209)		(210)		(222)
87	Fr	88	Ra	89	Ac	104	Rf	105	Db	106	Sg	107	Bh	108	Hs	109	Mt	110	Ds	111	Rg	112	Cn	113	Nh	114	Fl	115	Mc	116	Lv	117	Ts	118	Og
	(223)		(226)		(227)		(261)		(262)		(266)		(264)		(277)		(268)		(281)		(281)		(285)		(286)		(289)		(289)		(293)		(293)		(294)

58	Ce	59	Pr	60	Nd	61	Pm	62	Sm	63	Eu	64	Gd	65	Tb	66	Dy	67	Ho	68	Er	69	Tm	70	Yb	71	Lu
	140.1		140.9		144.2		(145)		150.4		152.0		157.3		158.9		162.5		164.9		167.3		168.9		173.0		175.0
90	Th	91	Pa	92	U	93	Np	94	Pu	95	Am	96	Cm	97	Bk	98	Cf	99	Es	100	Fm	101	Md	102	No	103	Lr
	232.0		231.0		238.0		(237)		(244)		(243)		(247)		(247)		(251)		(252)		(257)		(258)		(259)		(262)

Water Data

- $T_{mp} = 0^{\circ}\text{C}$
- $T_{bp} = 100^{\circ}\text{C}$
- $c_{ice} = 2.09 \text{ J/g}\cdot\text{K}$
- $c_{water} = 4.184 \text{ J/g}\cdot\text{K}$
- $c_{steam} = 2.03 \text{ J/g}\cdot\text{K}$
- $\Delta H_{fus} = 334 \text{ J/g}$
- $\Delta H_{vap} = 2260 \text{ J/g}$
- $K_f = 1.86 \text{ }^{\circ}\text{C}/m$
- $K_b = 0.512 \text{ }^{\circ}\text{C}/m$

Constants

- $R = 0.08206 \text{ L}\cdot\text{atm}/\text{mol}\cdot\text{K}$
- $R = 8.314 \text{ J}/\text{mol}\cdot\text{K}$
- $R = 62.36 \text{ L}\cdot\text{torr}/\text{mol}\cdot\text{K}$
- $e = 1.602 \times 10^{-19} \text{ C}$
- $N_A = 6.022 \times 10^{23} \text{ mol}^{-1}$
- $k = 1.38 \times 10^{-23} \text{ J/K}$
- $h = 6.626 \times 10^{-34} \text{ J}\cdot\text{s}$
- $c = 3.00 \times 10^8 \text{ m/s}$
- $R_H = 2.178 \times 10^{-18} \text{ J}$
- $m_e = 9.11 \times 10^{-31} \text{ kg}$
- $\mathcal{F} = 96,485 \text{ C/mol } e^{-}$
- 1 amp = 1 C/sec
- 1 mol e^{-} = 96,485 C

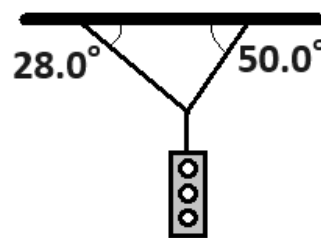
Acid Dissociation Constants

HClO: $K_a = 3.5 \times 10^{-8}$.

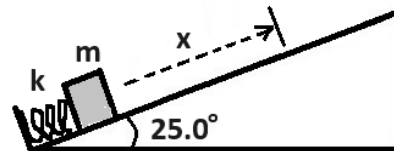
Conversion factors

1 L·atm = 101.325 J

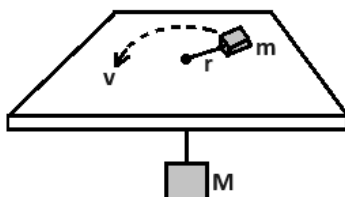
- P01. According to Guillen, Faraday worked at a bookbindery while he was young. His life changed forever when, while stitching together a copy of the *Encyclopedia Britannica*, he read the entry on _____.
- alchemy
 - chemistry
 - magnetism
 - electricity
 - relativity
- P02. According to Guillen, after the publication of his first article, Faraday was falsely accused of having plagiarized the idea for the article from William Wollaston. What idea was Faraday accused of plagiarizing?
- the compass
 - the liquification of chlorine
 - the dynamo
 - the electric motor
 - the telegraph
- P03. According to Guillen, Faraday always was adamant about expressing his discovery in a way that ordinary people could understand. Decades later, another physicist would translate Faraday's discovery into a mathematical equation. Who was this physicist?
- James Clerk Maxwell
 - Luigi Galvani
 - William Gilbert
 - Andre Ampere
 - Hans Christian Orsted
- P04. Stars similar in mass to the Sun are too small to produce a supernova when they die. Instead, they gradually cast off gas during their red giant phase. What do we call the astronomical object formed by the ejected gas from a dying low-mass star?
- a cold molecular cloud
 - a globular cluster
 - a coronal flare
 - a quasar
 - a planetary nebula
- P05. A helicopter starting at Brenham flies 80.0 miles in a direction that is 60.0° south of east. It then flies another 50.0 miles due west before landing. How far from Brenham is the helicopter when it lands?
- 30.0 miles
 - 70.0 miles
 - 94.3 miles
 - 113.6 miles
 - 130.0 miles
- P06. You throw a dog toy with a velocity of 13.5m/s at an angle of 41.0° above the horizontal. The toy is released from a height of 3.30m above the ground. How far away from you, horizontally, does the toy land on the ground? Ignore air resistance.
- 3.23 m
 - 8.37 m
 - 12.1 m
 - 18.9 m
 - 21.7 m
- P07. A 22.0kg stoplight is suspended by three cables, as shown. The upper left cable makes an angle of 28.0° with respect to the horizontal, and the upper right cable makes an angle of 50.0° with respect to the horizontal. The lower cable is vertical, and the system is in equilibrium. What is the tension in the upper left cable?
- 103 N
 - 125 N
 - 142 N
 - 168 N
 - 195 N



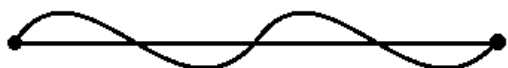
- P08. A spring with a spring constant of 890.0 N/m is compressed by 15.0cm. A box of cat litter with a mass of 2.20kg is placed up against the compressed spring. The spring and box are placed at the bottom of a frictionless inclined plane that is angled at 25.0° above the horizontal (as shown). The spring is then released. How far up the plane (distance x) does the box of cat litter slide?
- 110 cm
 - 92.8 cm
 - 72.0 cm
 - 51.2 cm
 - 46.4 cm



- P09. A small, 350.0g block (m) is attached to a string, and is moving in a circle on a frictionless table, as shown. The string passes through a small hole in the table and a 1.20kg mass is hanging from the end of the string. The radius of the circle traced out by the small block is 24.0cm. If the system is stable, then what is the tangential velocity, v , of the small block?



- A) 1.53 m/s
 B) 2.84 m/s
 C) 5.45 m/s
 D) 8.06 m/s
 E) 11.8 m/s
- P10. A 42.0cm long guitar string has a mass of 1.90g. The resonant vibration of the string that is illustrated below oscillates at a frequency of 868.0Hz. What is the tension in the string?

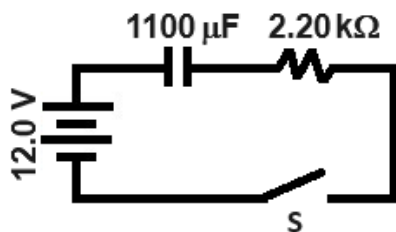


- A) 601 N
 B) 425 N
 C) 338 N
 D) 212 N
 E) 150 N
- P11. 250.0g of an unknown metal is heated to 100°C. The hot metal is placed in 200.0g of water that is initially at 10.0°C. The mixture of water and metal equilibrates to a final temperature of 24.2°C. What is the specific heat capacity of the unknown metal?

- A) 1.07 J/kgK
 B) 0.810 J/kgK
 C) 0.627 J/kgK
 D) 0.442 J/kgK
 E) 0.150 J/kgK

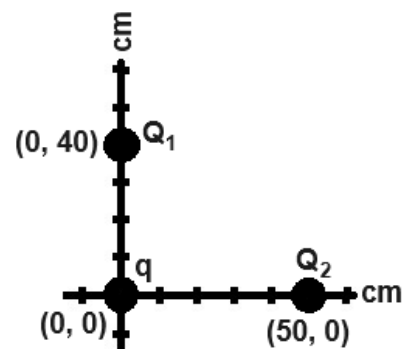
- P12. For the RC-circuit shown, find the current flowing in the circuit exactly 1.90 seconds after the switch S is closed? Note: The capacitor is initially uncharged.

- A) 2.49 mA
 B) 4.28 mA
 C) 4.98 mA
 D) 5.45 mA
 E) 10.9 mA



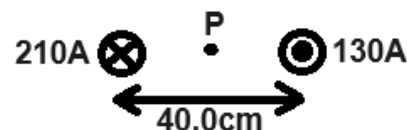
- P13. Three charges are placed on a coordinate system as shown. The first charge, $Q_1 = 16.0\mu\text{C}$, is placed at (0.0, 40.0cm). The second charge, $Q_2 = 30.0\mu\text{C}$, is placed at (50.0cm, 0.0). Calculate the net force of these two charges acting on the third charge, $q = -5.00\mu\text{C}$, which is placed at the origin (0, 0).

- A) 0.899 N
 B) 3.24 N
 C) 4.50 N
 D) 7.02 N
 E) 9.89 N



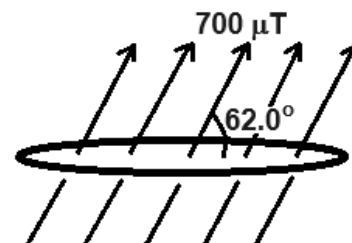
- P14. Two long, straight, current carrying wires run parallel to one another in the z -direction, as illustrated. The first wire carries a current of 130.0A in the $+z$ direction (out of the page) and the second wire carries a current of 210.0A in the $-z$ direction (into the page). The wires are separated by 40.0cm. What is the strength of the magnetic field halfway between the wires, at the point P ?

- A) 40.0 μT
 B) 80.0 μT
 C) 170 μT
 D) 340 μT
 E) 400 μT



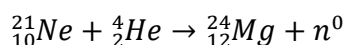
- P15. A 2.5Ω wire is curled into a single circular loop with a diameter of 30.0cm. The loop is placed flat (horizontal) on a table. A $700.0\mu\text{T}$ magnetic field passes through the loop at an angle of 62.0° with respect to the horizontal, as shown. If the magnetic field vanishes to zero in a time of 0.75ms, what current is induced in the wire loop?

- A) 106 mA
 B) 93.2 mA
 C) 59.8 mA
 D) 26.4 mA
 E) 23.3 mA



- P16. A single dog hair is illuminated by a 530nm laser, producing a diffraction pattern on a screen located 1.30m away from the hair. The diffraction fringes on the screen are separated by 2.20cm. What is the diameter of the dog hair?
- A) 15.7 μm
 B) 31.3 μm
 C) 53.0 μm
 D) 61.6 μm
 E) 89.7 μm
- P17. The atoms in a Bose-Einstein Condensate have been cooled to the point that their velocities are extremely low. Suppose atoms of sodium (mass 3.82×10^{-26} kg) are slowed to a speed of 0.250mm/s. To what minimum physical size do the wavefunctions of these very cold atoms extend?
- A) 5.5 μm
 B) 3.4 μm
 C) 2.2 μm
 D) 1.4 μm
 E) 0.88 μm

- P18. You observe the following fusion reaction. How much energy is released by this reaction?

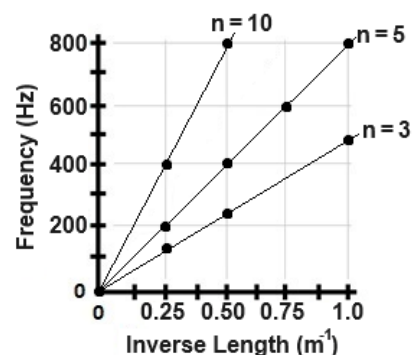


The mass of Neon-21 is 20.9938467u, the mass of Helium-4 is 4.002603u, and the mass of Magnesium-24 is 23.98504170u.

- A) 1.01 MeV
 B) 2.56 MeV
 C) 2.99 MeV
 D) 5.15 MeV
 E) 9.32 MeV

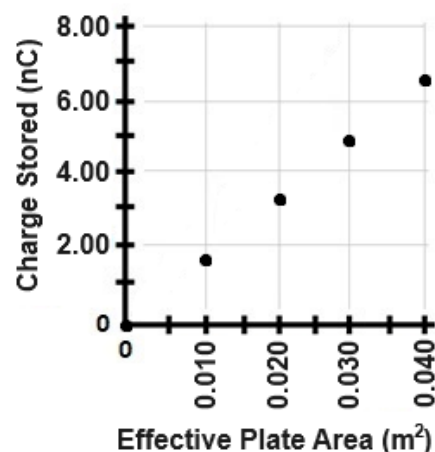
- P19. While playing a trombone, you adjust the extension of the slide to produce specific frequencies, recording the total pipe length and harmonic for each frequency produced. You plot the frequency, f , versus the inverse of the pipe length, L^{-1} , for each harmonic (shown below). Based on these data, what is the speed of sound in the trombone?

- A) 380 m/s
 B) 360 m/s
 C) 340 m/s
 D) 320 m/s
 E) 300 m/s



- P20. You sandwich a sheet of glass between two metal plates to form a capacitor. The plates are fixed at a separation of 1.25cm (the thickness of the glass), and you can vary the effective area of the capacitor by changing the alignment of the two plates. For different alignments, you measure the effective area, as well as the total charge stored on the capacitor when it is connected to a 12.0V battery. The data are plotted below. Based on the data, determine the dielectric constant of the glass.

- A) 12
 B) 16
 C) 19
 D) 23
 E) 27



Physics

Useful Constants

quantity	symbol	value
Free-fall acceleration	g	9.80 m/s^2
Permittivity of Free Space	ϵ_0	$8.854 \times 10^{-12} \text{ C}^2/\text{Nm}^2$
Permeability of Free Space	μ_0	$4\pi \times 10^{-7} \text{ Tm/A}$
Coulomb constant	k	$8.99 \times 10^9 \text{ Nm}^2/\text{C}^2$
Speed of light in a vacuum	c	$3.00 \times 10^8 \text{ m/s}$
Fundamental charge	e	$1.602 \times 10^{-19} \text{ C}$
Planck's constant	h	$6.626 \times 10^{-34} \text{ Js}$
Electron mass	m_e	$9.11 \times 10^{-31} \text{ kg}$
Proton mass	m_p	$1.67265 \times 10^{-27} \text{ kg}$ 1.007276 amu
Neutron mass	m_n	$1.67495 \times 10^{-27} \text{ kg}$ 1.008665 amu
Atomic Mass Unit	amu	$1.66 \times 10^{-27} \text{ kg}$ $931.5 \text{ MeV}/c^2$
Gravitational constant	G	$6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$
Stefan-Boltzmann constant	σ	$5.67 \times 10^{-8} \text{ W/m}^2\text{K}^4$
Universal gas constant	R	$8.314 \text{ J/mol} \cdot \text{K}$ $0.082057 \text{ L} \cdot \text{atm/mol} \cdot \text{K}$
Boltzmann's constant	k_B	$1.38 \times 10^{-23} \text{ J/K}$
Speed of Sound (at 20°C)	v	343 m/s
Avogadro's number	N_A	$6.022 \times 10^{23} \text{ atoms/mol}$
Electron Volts	eV	$1.602 \times 10^{-19} \text{ J/eV}$
Distance Conversion	miles \rightarrow meters	1.00 mile = 1609 meters
Rydberg Constant	R_∞	$1.097 \times 10^7 \text{ m}^{-1}$
Standard Atmospheric Pressure	1 atm	$1.013 \times 10^5 \text{ Pa}$
Density of Pure Water	ρ_{water}	1000.0 kg/m^3
Specific Heat Capacity of Water	c_{water}	$4.186 \text{ J/kg} \cdot \text{K}$