UNIVERSITY INTERSCHOLASTIC LEAGUE

Science

Invitational A • 2025

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 is not a member of the endomembrane system of the eukaryotic cell?
A) rough endoplasmic reticulum
B) Golgi apparatus
C) nuclear envelope
D) mitochondria
E) smooth endoplasmic reticulum

B02. Emesis directly affects the _____ system.
A) integumentary
B) nervous
C) digestive
D) cardiovascular
E) skeletal

B03. The ribosome is made of
A) DNA and rRNA.
B) protein and tRNA.
C) DNA and protein.
D) rRNA and protein.
E) mRNA and rRNA.

B04. Smooth, cardiac, and skeletal are three types of ____ ___ tissue.
A) muscle
B) connective
C) nervous
D) epithelial
E) integumentary

B05. Scarlet Macaws and Great Green Macaws have been historically pre-zygotically separated by tall mountain ranges with cooler weather. Due to climate change, the weather in the mountains is warmer, which has provided an avenue for Scarlet Macaws to move across the barrier and mate with Great Green Macaws. What is a possible outcome of this hybridization?
A) Increase in genetic variation
B) Increase in speciation
C) Wasted reproductive effort and resources
D) Extinction
E) All of the above are possible outcomes.

B06. Malaria is caused by species belonging to Genus ___ ___ and is spread by mosquitoes of Genus
A) *Trypanosoma*; *Aedes*.
B) *Plasmodium*; *Anopheles*.
C) *Plasmodium*; *Aedes*.
D) *Trypanosoma*; *Anopheles*.
E) *Plasmodium*; *Culex*.

B07. DNA replication in eukaryotes occurs within the
A) nucleus.
B) nucleolus.
C) cytoplasm.
D) nucleoid.
E) ribosome.

B08. From the human perspective, lice are
A) endoparasites.
B) ectoparasites.
C) commensals.
D) mutualistic.
E) biological vectors.

B09. The majority of biochemical reactions of cellular respiration occur
A) in the nucleus.
B) outside the cell.
C) in the mitochondria.
D) in the plasma membrane.
E) within the endoplasmic reticulum.

B10. Which major macromolecular group contains molecules that store energy in the long-term?
A) Proteins
B) Nucleic acids
C) Carbohydrates
D) Amino acids
E) Lipids

B11. In a population at Hardy-Weinberg equilibrium, which value in the mathematical formula(s) represents the frequency of homozygous recessive individuals in the population?
A) p^2
B) p
C) q^2
D) q
E) 2pq

B12. What major event is occurring in cytokinesis of the eukaryotic cell cycle?
A) Condensation of the chromosomes
B) DNA replication
C) Cellular growth
D) Formation of the spindle apparatus
E) Division of the cytoplasm

B13. Which of the following is an effect of not regulating gene expression?
A) Upregulation of protein synthesis
B) Downregulation of protein synthesis
C) Prevention of gene expression
D) Cancer
E) All of the above are effects of not regulating gene expression.

B14. *Jacana spinosa* is a bird native to Costa Rica. During the breeding season, one female *Jacana* sp. mates with multiple males and maintains several different nesting sites, which are incubated by the males. This type of mating system is specifically called
A) monogamy.
B) polygyny.
C) polygynandry.
D) polyandry.
E) polygamy.

B15. The Centers for Disease Control and Prevention issued a Food Safety Alert in October 2024 for McDonald's onions due to possible contamination with
A) *Escherichia coli* O27.
B) *Escherichia coli* O157:H7.
C) *Salmonella*.
D) *Listeria*.
E) Measles.

B16. *Homo sapiens* and *Homo habilis* belong to all of the following except
A) Order
B) Family
C) Kingdon
D) Species
E) Genus

B17. Which technology would be used to amplify a DNA target sequence on the genome?
A) PCR
B) DNA gel electrophoresis
C) Northern Blot
D) Southern Blot
E) Western Blot

B18. Consider the F2 generation of Mendel's pea plants. If 16 progeny were produced in this generation from a dihybrid cross, statistically, how many of the 16 would be homozygous dominant for both traits?
A) 1
B) 3
C) 6
D) 8
E) 16

B19. The ornate and often colorful patterns on male birds is most derived from
A) genetic drift.
B) sexual selection by females.
C) abundancy of resources.
D) macroevolution.
E) environmental factors.

B20. Protein synthesis is to _____ as cellular respiration is to _____.
A) anabolism; anabolism
B) catabolism; catabolism
C) anabolism; catabolism
D) catabolism; anabolism

C01. What is the molar mass of K_2CO_3?

A) 39.10 g/mol
B) 67.11 g/mol
C) 106.21 g/mol
D) 126.20 g/mol
E) 138.21 g/mol

C02. What is the sum of the coefficients when this reaction is balanced using the smallest whole number coefficients?

$$H_3PO_4(aq) + KOH(aq) \rightarrow K_3PO_4(aq) + H_2O(\ell)$$

A) 4 B) 6 C) 8 D) 10 E) 12

C03. Which of these statements is true when an electron in an oxygen atom falls from $n = 5$ to $n = 2$?

A) Electricity is given off.
B) Light is emitted.
C) Sound is produced.
D) Another electron goes from $n = 2$ to $n = 5$.
E) The charge on the atom decreases.

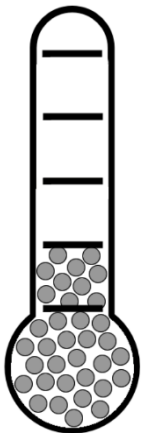
C04. According to valence bond theory, which of these is an example of a hybrid atomic orbital used in forming a covalent bond?

A) sp^3 B) s C) s^2p D) p^2 E) π

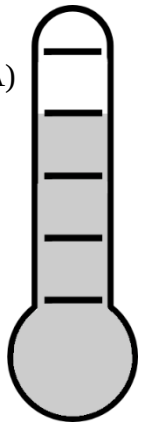
C05. A mole of gas at STP takes up 22.4 liters. How hot would you have to heat the gas to make it take up twice that volume at 1 atm?

A) 0 °C
B) 25.0 °C
C) 44.8 °C
D) 100 °C
E) 273 °C

C06. This image shows a thermometer at a low temperature. Which of the following images best represents the same thermometer at a higher temperature?



A)



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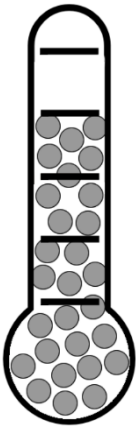
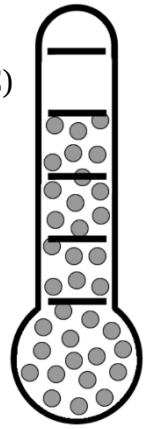
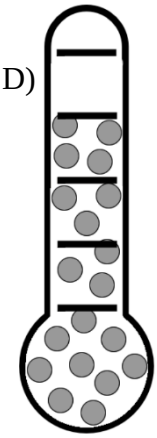


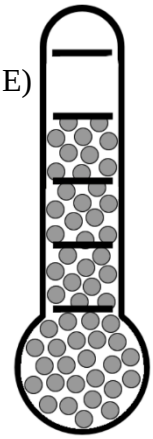
C)



D)



E)



C07. If you have 100 mL of 0.10 M HCl and you add 100 mL of water, what is the new pH of the solution?

A) 1.0 B) 1.3 C) 0.5 D) 2.0 E) 2.3

C08. How much heat is given off when 100.0 grams of propanol (C_3H_8O) is burned? The heat of combustion for propanol is –2021 kJ/mol.

A) 20.21 kJ B) 2.021 kJ
C) 3362 kJ D) 5600 kJ
E) 1.215×10^5 J

C09. An aluminum cylinder at a temperature of 88.0°C is dropped into 125 grams of water at a temperature of 25.0°C. If the final temperature of the water and the aluminum is 25.8°C, what is the mass of the aluminum cylinder? c_{Al} = 0.897 J/g°C

A) 7.5 g B) 8.0 g C) 8.5 g
D) 9.0 g E) 9.5 g

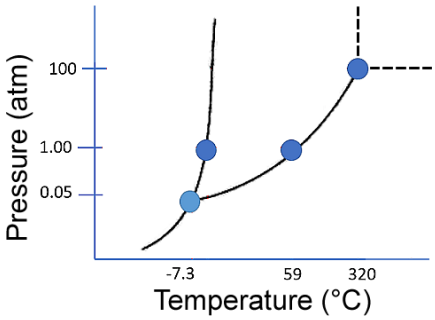
C10. Which of these determines the ratio of products to reactants in an equilibrium reaction that has reached equilibrium?

A) The amount of reactants you start with
B) The amount of products present in the starting mixture
C) The strength of the intermolecular forces between the reactant molecules and the product molecules.
D) The speeds of the forward and backward reactions.
E) At equilibrium the ratio of products to reactants always equals 1.

C11. Which combination of aqueous reagents below will result in the formation of a solid precipitate?

A) $AgNO_3$ + NaCl
B) $NaNO_3$ + $Pb(NO_3)_2$
C) NaCl + KBr
D) $NaHCO_3$ + NaOH
E) All of these

C12. This is an unlabeled phase diagram for an unknown compound. What physical state is the compound in under ordinary laboratory conditions?



A) Bose-Einstein Condensate
B) Solid
C) Liquid
D) Gas
E) Supercritical Fluid

C13. What type of attraction holds neighboring molecules together in a covalent liquid?

A) Covalent bonds
B) Ionic bonds
C) Magnetic attraction forces
D) Intermolecular forces
E) Delta Forces

C14. Propane gas (C_3H_8) is completely combusted using excess O_2 gas. What are the products of the combustion reaction?

A) CO_2
B) CO_2 and H_2O
C) CO_2 and CO
D) CO and H_2O
E) CO_2 and CH_4

C15. What is the difference between the formal charge and the oxidation number on an atom in a compound?

A) Nothing. The oxidation number of an atom in a compound is the same as the formal charge on that atom.
B) Formal charges are always the actual ionic charge on the atom and oxidation numbers are not.
C) Oxidation numbers are always the actual ionic charge on the atom and formal charges are not.
D) Formal charges are based on bonding electrons being shared equally and oxidation numbers are based on no shared electrons.
E) Oxidation numbers are based on bonding electrons being shared equally and formal charges are based on no shared electrons.

C16. How many mL of water would you have to add to 75.0 mL of a 5.00 M stock solution in order to create a solution with a concentration of 4.00 M?

A) 18.75 mL
B) 25.0 mL
C) 93.75 mL
D) 15.0 mL
E) 60.0 mL

C17. Which of these is not a real covalent compound name?

A) nitrogen triiodide
B) sulfur hexafluoride
C) dinitrogen pentoxide
D) carbon tetrachloride
E) monophosphorus monoxide

C18. Aluminum fluoride, AlF_3, is usually made by fluorinating aluminum metal using HF gas. How many grams of aluminum fluoride could you make from 225 grams of solid aluminum and excess HF gas?

A) 700 g
B) 675 g
C) 525 g
D) 450 g
E) 225 g

C19. How many atoms are there in a 16.0 L sample of CO_2 gas at 79 °C and 1.0 atm pressure?

A) 3.34×10^{23} atoms
B) 1.00×10^{24} atoms
C) 4.05×10^{25} atoms
D) 6.02×10^{23} atoms
E) 6.64×10^{23} atoms

C20. You are trying to carry out a reaction between a solid reactant and an aqueous reactant, but the reaction is going too slow. Which of these changes would speed up the reaction?

A) heat the solution
B) chop up the solid reactant into smaller pieces
C) add more solid reactant
D) increase the concentration of the aqueous reactant
E) all of these

P01. According to Orzel, observers moving at constant speed relative to each other define a special group of….
A) velocity transforms
B) reference transforms
C) inertial frames
D) relative frames
E) acceleration frames

P02. According to Orzel, Maxwell's equations translate into four simple rules. Which of these choices is NOT one of the rules derived from Maxwell's Equations?
A) The strength of an electric field depends on the amount of charge in the vicinity.
B) The strength of a magnetic field depends on the number of poles in the vicinity.
C) A magnet will always have both north and south poles.
D) An electric field is created by a changing magnetic field.
E) A magnetic field is created by either a current or a changing electric field.

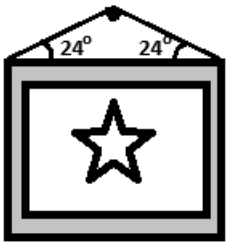
P03. According to Orzel, the experiment to look for the effects of motion on the speed of light was carried out by....
A) Poincare and Einstein
B) Hertz and Lorentz
C) FitzGerald and Lorentz
D) Michaelson and Hertz
E) Michaelson and Morley

P04. The atmosphere of Venus is primarily composed of what gas?
A) Nitrogen
B) Oxygen
C) Carbon Dioxide
D) Sulfur Dioxide
E) Carbon Monoxide

P05. A marathon runner travels 1500 feet in 2.8 minutes. What is the runner's speed in meters per second?
A) 2.7 m/s
B) 3.8 m/s
C) 5.4 m/s
D) 7.6 m/s
E) 8.9 m/s

P06. You are resting on the ground when an angry fairy throws an acorn at you. The acorn is thrown straight down from a height of 4.40m above you, and with an initial velocity of 8.60m/s. How fast is the acorn moving when it hits you?
A) 8.60 m/s
B) 10.8 m/s
C) 12.7 m/s
D) 15.2 m/s
E) 17.9 m/s

P07. A 1.20kg framed picture is hung on a wall using a single wire looped over a nail, as shown. The wire makes an angle of 24.0° with respect to horizontal on both sides of the frame. What is the tension in the wire?
A) 12.0 N
B) 14.4 N
C) 19.2 N
D) 24.1 N
E) 28.9 N



P08. After being hit with an acorn, you angrily throw it directly upwards. The mass of the acorn is 2.50g and you throw it with an initial kinetic energy of 0.180J. Assuming it doesn't hit anything, how high above you does the acorn go after you throw it?
A) 2.94 m
B) 4.40 m
C) 6.00 m
D) 7.35 m
E) 12.0 m

P09. A circular disk with a radius of 25.0cm starts from rest. The disk spins up with an angular acceleration of 30.0rad/s^2 until it reaches a final angular velocity of 150rpm. How long does it take to reach this final angular velocity?
A) 5.00 sec
B) 2.10 sec
C) 1.25 sec
D) 0.524 sec
E) 0.131 sec

P10. A 300.0g mass is attached to a vertical spring and released, after which the mass-spring system oscillates with a period of 0.855 seconds. What is the spring constant of the spring?

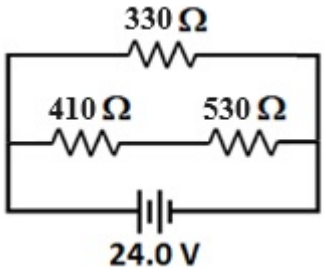
A) 1.01 N/m
B) 2.20 N/m
C) 7.33 N/m
D) 13.5 N/m
E) 16.2 N/m

P11. A metal pipe is measured to have a length of 3.311m at a temperature of −15.0°C. At a temperature of +42.0°C, the pipe is measured to be 3.324m in length. What is the coefficient of thermal expansion for the metal pipe?

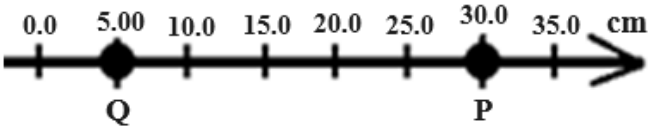
A) 4.8×10^{-4} °C^{-1}
B) 2.3×10^{-4} °C^{-1}
C) 1.5×10^{-4} °C^{-1}
D) 6.9×10^{-5} °C^{-1}
E) 4.4×10^{-5} °C^{-1}

P12. For the circuit shown below, what is the current flowing through the 530Ω resistor?

A) 25.5 mA
B) 45.3 mA
C) 58.5 mA
D) 72.7 mA
E) 98.3 mA



P13. A charge, $Q = 33.0nC$, is placed on a horizontal axis as shown below. Find the magnitude of the electric potential at the point P (also on the axis) due to the charge Q.



A) 990 V
B) 1190 V
C) 2960 V
D) 4750 V
E) 5930 V

P14. A fast-moving proton enters a region of magnetic field. The field strength is 450 Gauss, and the field is oriented perpendicular to the motion of the proton. If the proton traces out a circle with a diameter of 26.0cm, then what is the magnitude of the velocity of the proton?

A) 3.50×10^5 m/s
B) 5.04×10^5 m/s
C) 5.60×10^5 m/s
D) 8.40×10^5 m/s
E) 1.12×10^6 m/s

P15. A rectangular loop of wire is 30.0cm long, 15.0cm wide, and has a resistance of 1.20Ω. Initially, a 220 Gauss magnetic field passes through the loop, oriented perpendicular to the face of the loop. The magnetic field drops to zero in a time of 62.0μs. What is the magnitude of the current induced in the loop due to the changing magnetic field?

A) 16.0 A
B) 13.3 A
C) 8.87 A
D) 4.44 A
E) 2.96 A

P16. A moth with a wingspan of 5.00cm flies 56.0cm in front of a concave mirror. The mirror has a radius of curvature of 200.0cm. What is the wingspan of the image of the moth formed by the mirror?

A) 3.21 cm
B) 3.91 cm
C) 6.94 cm
D) 8.45 cm
E) 11.4 cm

P17. Light with a wavelength of 455nm is directed onto a metal surface, resulting in electrons being emitted from the surface. The workfunction of the metal is 2.28eV. What is the velocity of the electrons that are emitted from the surface?

A) 4.45×10^4 m/s
B) 1.57×10^5 m/s
C) 1.98×10^5 m/s
D) 2.73×10^5 m/s
E) 3.96×10^5 m/s

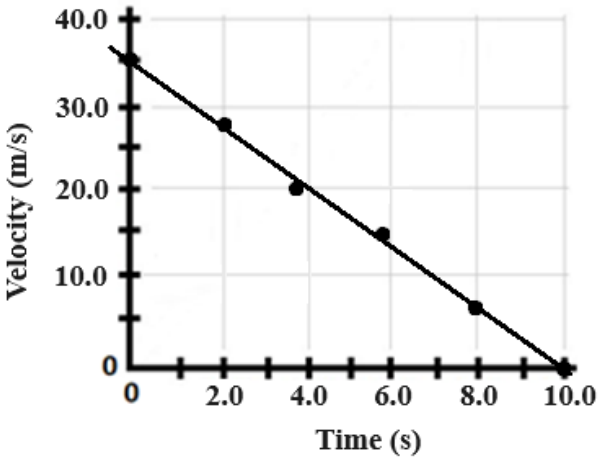
P18. An atom of Copernicium ($^{285}_{112}Cn$) undergoes the following radioactive decays:

$$\alpha\ ,\ \alpha\ ,\ \gamma\ ,\ \beta^-\ ,\ \alpha\ ,\ \gamma\ ,\ \beta^-$$

What is the daughter isotope resulting from this series of radioactive decays?

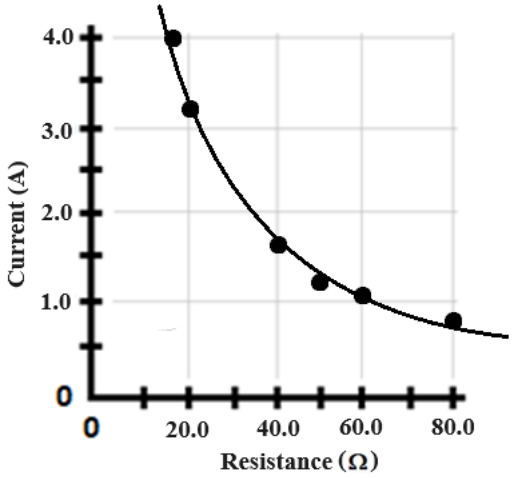
A) $^{273}_{108}Hs$
B) $^{275}_{108}Hs$
C) $^{271}_{104}Rf$
D) $^{273}_{104}Rf$
E) $^{275}_{104}Rf$

P19. The plot below illustrates the velocity of a small boat as a function of time. Based on these data, what is the acceleration of the boat?



A) $-1.5\ \mathrm{m/s^2}$
B) $-2.3\ \mathrm{m/s^2}$
C) $-3.5\ \mathrm{m/s^2}$
D) $-4.4\ \mathrm{m/s^2}$
E) $-5.8\ \mathrm{m/s^2}$

P20. You have a power supply that produces an unknown voltage. You connect the supply to different resistors and measure the current for each resistance. The data are plotted below. Based on these data, what is the magnitude of the voltage produced by the power supply?



A) 25 V
B) 40 V
C) 50 V
D) 65 V
E) 100 V

Chemistry

1A 1												3A 13	4A 14	5A 15	6A 16	7A 17	8A 18
1 H 1.01	2A 2																2 He 4.00
3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31	3B 3	4B 4	5B 5	6B 6	7B 7	8	8B 9	10	1B 11	2B 12	13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.64	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La 138.9	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.20	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (281)	111 Rg (281)	112 Cn (285)	113 Nh (286)	114 Fl (289)	115 Mc (289)	116 Lv (293)	117 Ts (293)	118 Og (294)

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

Water Data

T_{mp} = 0°C
T_{bp} = 100°C
c_{ice} = 2.09 J/g·K
c_{water} = 4.184 J/g·K
c_{steam} = 2.03 J/g·K
ΔH_{fus} = 334 J/g
ΔH_{vap} = 2260 J/g
K_f = 1.86 °C/*m*
K_b = 0.512 °C/*m*

Constants

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

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Physics

Useful Constants

quantity	symbol	value
Free-fall acceleration	g	$9.80\ m/s^2$
Permittivity of Free Space	ε_0	$8.854 \times 10^{-12}\ C^2/Nm^2$
Permeability of Free Space	μ_0	$4\pi \times 10^{-7}\ Tm/A$
Coulomb constant	k	$8.99 \times 10^{9}\ Nm^2/C^2$
Speed of light in a vacuum	c	$3.00 \times 10^{8}\ m/s$
Fundamental charge	e	$1.602 \times 10^{-19}\ C$
Planck's constant	h	$6.626 \times 10^{-34}\ Js$
Electron mass	m_e	$9.11 \times 10^{-31}\ kg$
Proton mass	m_p	$1.67265 \times 10^{-27}\ kg$ $1.007276 amu$
Neutron mass	m_n	$1.67495 \times 10^{-27}\ kg$ $1.008665 amu$
Atomic Mass Unit	amu	$1.66 \times 10^{-27}\ kg$ $931.5\ MeV/c^2$
Gravitational constant	G	$6.67 \times 10^{-11}\ Nm^2/kg^2$
Stefan-Boltzmann constant	σ	$5.67 \times 10^{-8}\ W/m^2K^4$
Universal gas constant	R	$8.314\ J/mol \cdot K$ $0.082057\ L \cdot atm/mol \cdot K$
Boltzmann's constant	k_B	$1.38 \times 10^{-23}\ J/K$
Speed of Sound (at 20ºC)	v	343 m/s
Avogadro's number	N_A	$6.022 \times 10^{23}\ atoms/mol$
Electron Volts	eV	$1.602 \times 10^{-19}\ J/eV$
Distance Conversion	miles → meters inches → centimeters	1.0 mile = 1609 meters 1.00 inch = 2.54 centimeters
Rydberg Constant	R_∞	$1.097 \times 10^{7}\ m^{-1}$
Standard Atmospheric Pressure	1 atm	$1.013 \times 10^{5}\ Pa$
Density of Pure Water	ρ_{water}	$1000.0\ kg/m^3$
Magnetic Field Conversion	Gauss → Tesla	10^4 Gauss = 1.00 Tesla

DO NOT DISTRIBUTE TO STUDENTS BEFORE OR DURING THE CONTEST!

UIL HIGH SCHOOL SCIENCE CONTEST
ANSWER KEY
2025 INVITATIONAL A

Biology	Chemistry	Physics
B01. D	C01. E	P01. C
B02. C	C02. C	P02. B
B03. D	C03. B	P03. E
B04. A	C04. A	P04. C
B05. E	C05. E	P05. A
B06. B	C06. D	P06. C
B07. A	C07. B	P07. B
B08. B	C08. C	P08. D
B09. C	C09. A	P09. D
B10. E	C10. D	P10. E
B11. C	C11. A	P11. D
B12. E	C12. C	P12. A
B13. E	C13. D	P13. B
B14. D	C14. B	P14. C
B15. B	C15. D	P15. B
B16. D	C16. A	P16. E
B17. A	C17. E	P17. E
B18. A	C18. A	P18. A
B19. B	C19. B	P19. C
B20. C	C20. E	P20. D

CHEMISTRY SOLUTIONS – UIL INVITATIONAL A 2025

C01. (E) $2\times39.10 + 12.01 + 3\times16.00 = 138.21$ g/mol

C02. (C) $1\ H_3PO_4(aq) + 3\ KOH(aq) \rightarrow 1\ K_3PO_4(aq) + 3\ H_2O(\ell)$

C03. (B) Electrons falling from higher energy levels to lower energy levels in an atom give off the difference in energy as light.

C04. (A) In valence bond theory, *s*, *p*, and *d* orbitals in an isolated atom can combine to form an equal number of degenerate energy hybridized orbitals. The names of the hybridized orbitals are the isolated atomic orbitals that went into creating the hybridized orbital, so sp^3 hybridized orbitals are made up of one *s* and three *p* orbitals for a total of four equal-energy sp^3 orbitals, allowing the atom to form four equal-energy single bonds like the carbon atom in methane.

C05. (E) PV = nRT so T = PV/nR. N = 1, V = 44.8 L, P = 1 atm. R = 0.08206 L·atm/mol·K
T = (1)(44.8)/(1)(0.08206) = 545.94 K = 273 °C. Or since you are doubling the volume, you need to double the temperature, from 273 K (STP) to 576 K = 273 °C.

C06. (C) The liquid in the thermometer "rises" because it expands by increasing the amount of space between the particles. At higher temperatures the thermometer will have the same number of particles in it and they will still be the same size, but they will be moving faster and will be spaced farther apart.

C07. (B) The new concentration is one half of the original, or 0.05 M. –log(0.05) = 1.3

C08. (C) The molar mass of propanol is 60.11, so 100.0 grams is 1.664 moles.
The *change in heat* is 1.664 moles × –2021 kJ/mol = –3362 kJ, so the amount of heat *given off* is 3362 kJ.

C09. (A) $-m_{Al}c_{Al}\Delta T_{Al} = m_{water}c_{water}\Delta T_{water}$
c_{Al} = 0.897 J/g°C
ΔT_{Al} = (25.8 – 88.0) = –62.2 °C
m_{water} = 125 g
c_{water} = 4.184 J/g°C
ΔT_{water} = (25.8 – 25.0) = 0.8 °C

$$m_{Al} = \frac{-m_w c_w \Delta T_w}{c_{Al}\Delta T_{Al}} = \frac{-(125)(4.184)(0.8)}{(0.897)(-62.2)} = 7.5 \text{ g}$$

(ΔT_{water} = limits our final answer to only one significant digits.)

C10. (D) The equilibrium constant *K* is determined by the ratio of the forward and backward reaction rates.

C11. (A) AgCl is insoluble in water. None of the other combinations result in a product that is insoluble in water.

C12. (C) Ordinary lab conditions are 1 atm pressure and about 25°C, which is the liquid region on the graph.

C13. (D)

C14. (B) Complete combustion reactions of hydrocarbons (as well as oxygen-containing organic compounds) always produce CO_2 and H_2O as the products. Incomplete combustion (which is the norm in real life fires) produces all kinds of partial combustion products including carbon monoxide.

C15. (D) The Formal charge on an atom in a compound assumes all electrons are shared equally and oxidation numbers treat all bonds as if they are ionic. Although oxidation numbers are the same as the charge on a monatomic ion, the oxidation numbers on atoms in a polyatomic ion are not the same as the charge on the ion (but they all add up to the total charge).

C16. (A) $M_1V_1 = M_2V_2$. $M_1 = 5.00$, $V_1 = 75.0$, $M_2 = 4.00$, $V_2 = (5.00)(75.0)/4.00 = 93.75$ mL. that is the *total* volume of the 4.00 M solution, and you start with 75.0 mL of stock, so you need to add 93.75 – 75.0 = 18.75 mL.

C17. (E) When naming covalent compounds you do not put a *mono-* prefix on the first element in the compound name. For example, it's carbon dioxide and carbon monoxide, not monocarbon dioxide and monocarbon monoxide. The *mono-* prefix is used only on the second element in the compound name in a binary covalent compound. PO is an unstable compound called *phosphorus monoxide*.

C18. (A) 225 g / 26.98 g/mol = 8.3395 mol Al = 8.3395 mol AlF_3.
8.3395 mol AlF_3 × 83.98 g/mol = 700.35 grams AlF_3.

C19. (B) $PV=nRT$, so $n = PV/RT$. $T = 79+273=352$ K. $n = (1)(16)/(0.08206\times352) = 0.5539$ moles of $CO_2 \times 6.022 \times 10^{23} = 3.336 \times 10^{23}$ molecules. There are three atoms per CO_2 molecule, so number of atoms = 3.336×10^{23} molecules × 3 atoms/molecule = 1.00×10^{24} atoms.

C20. (E) B and C both have the effect of increasing the surface area of the solid, allowing for more interactions with the aqueous reactant. BTW, there is one more way to speed up a chemical reaction that is not listed here…

PHYSICS SOLUTIONS – UIL INVITATIONAL A 2025

P01. (C) page 23: "Observers moving at constant speed relative to each other define a special group of inertial frames, so called because they are frames of reference in which Newton's principle of inertia (the first law) holds true."

P02. (B) pages 34-35: "While Maxwell's Equations may look intimidating in mathematical notation, they're actually very simple to translate into English…. The four equations translate into four rules:
1. The strength of an electric field depends on the amount of charge in the vicinity.
2. A magnet will always have both north and south poles.
3. An electric field is created by a changing magnetic field.
4. A magnetic field is created by either a current or a changing electric field."

P03. (E) page 40: "The most famous experiment to look for the effects of motion on the speed of light is known to physicists as the Michaelson-Morley experiment; it was carried out by American physicist Albert Michaelson with the assistance of Edward Morley, starting in the 1880s."

P04. (C) Venus's atmosphere is composed of about 95% carbon dioxide. It has some nitrogen (3%) and trace amounts of sulfur dioxide, carbon monoxide, water vapor and argon. The high level of carbon dioxide has caused a runaway greenhouse effect, making Venus the hottest planet in the solar system.

P05. (A) First, we should convert the given quantities to metric units. One meter equals 3.28 feet. This means that 1500 feet is $d = \frac{1500ft}{3.28ft/m} = 457$m. For time, we get $t = (2.8min) * (60\frac{sec}{min}) = 168\ s$. To find velocity, we divide distance by time, which gives: $v = \frac{d}{t} = \frac{455m}{168\ s} = 2.7\ m/s$.

P06. (C) We do not know how long the acorn was in the air, but we do know the distance it traveled through the air. So, we'll use the equation that does not involve time: $v_f^2 = v_i^2 + 2a\Delta y$. Plugging in the given values, we get $v_f^2 = (8.60)^2 + 2(9.80)(4.40) = 160.2 \ \rightarrow \ v_f = 12.7$m/s.

P07. (B) We begin with a force diagram for the framed picture. There are three forces: gravity (mg, directed downward), tension on the left (T_L, directed up and right), and tension on the right (T_R, directed up and left). Since both tensions act at an angle, we must consider their components. In the x-direction, we have $T_L \cos\theta$ on the left, and $-T_R \cos\theta$ on the right. In the y-direction, we get $T_L \sin\theta$ on the left and $T_R \sin\theta$ on the right. The picture is in static equilibrium, so all of the forces in each direction must sum to zero. In the x-direction, we get $\sum F_x = T_L \cos\theta - T_R \cos\theta = 0$. This leads to $T_L \cos(24.0) = T_R \cos(24.0) \ \rightarrow \ T_L = T_R$. We could already surmise this based on the symmetry of the problem. Let's call the tensions on each side T since they are the same $T = T_L = T_R$. For the y-direction, we get $\sum F_y = T_L \sin\theta + T_R \sin\theta - mg = 0$. Renaming the tensions, and putting in the numbers, we get $T \sin(24.0) + T \sin(24.0) = (1.20)(9.80)$. This gives $2T \sin(24.0) = 11.76 \ \rightarrow \ 0.8135T = 11.76 \ \rightarrow \ T = 14.4$N.

P08. (D) Since we are given the initial kinetic energy, it makes sense to use conservation of energy to solve the problem. As the acorn rises, its kinetic energy is converted into gravitational potential energy. At its maximum height, all of the kinetic energy has become gravitational potential energy: $KE_i = GPE_f = 0.180$J. Putting in the equation for gravitational potential energy, we obtain the maximum height of the acorn:
$GPE_f = mgh_f = 0.180 \ \rightarrow \ (2.50 \times 10^{-3})(9.80)h_f = 0.180$. This gives $h_f = 7.35$m.

P09. (D) First, we need to convert the final angular velocity into the proper units: $\omega_f = 150\frac{rev}{min} * \frac{2\pi\, rad}{1\, rev} * \frac{1\, min}{60\, sec} = 15.71$rad/s. Now we use the angular kinematic equation: $\omega_f = \omega_i + \alpha t \;\rightarrow\; 15.71 = 0 + (30.0)t$ This leads to $t = 0.524$ sec. Note: The radius of the disk is given but isn't needed.

P10. (E) The period of a mass-spring system is given by the equation $T = 2\pi\sqrt{\frac{m}{k}}$. Rearranging to solve for the spring constant gives $k = \left(\frac{2\pi}{T}\right)^2 m$. Converting the mass into kilograms, and plugging in the known values, results in a spring constant of $k = \left(\frac{2\pi}{0.855}\right)^2 (0.300) = 16.2$ N/m.

P11. (D) The equation that describes thermal expansion is $\Delta L = L_0\alpha\Delta T$. First, we'll find the change in length from cold to hot: $\Delta L = 3.324 - 3.311 = 0.013$m. Using the cold length as the original length, L_0, we get: $0.013 = (3.311)\alpha\big(42 - (-15)\big) \;\rightarrow\; 0.013 = (3.311)(57)\alpha$. So, the coefficient of thermal expansion is $0.013 = 188.7\alpha \;\rightarrow\; \alpha = 6.9 \times 10^{-5}\ °C^{-1}$.

P12. (A) The two middle resistors, the 410Ω and the 530Ω, are in series, so we'll start by combining them. This gives a middle branch resistance of $R_M = 410 + 530 = 940\Omega$. This middle resistance is in parallel with the upper resistor (330Ω). Branches in parallel will all have the same voltage across them, which means that the voltage across the 330Ω resistor is $V_U = 24.0$V, and the voltage across the middle branch is also $V_M = 24.0$V. This also means that we don't need to combine the last two resistances. Now that have the middle branch voltage, we use Ohm's law to find the middle branch current: $V_M = I_M R_M \;\rightarrow\; 24 = I_M(940)$. This gives a middle branch current of $I_M = 0.0255$A. For resistors in series the currents flowing through each resistor will be the same as the total current in the branch, so the current through each of the middle branch resistors is that same value. That is, $I_{530} = I_{410} = I_M = 0.0255A = 25.5$mA.

P13. (B) The equation for the electric potential produced by a point charge is $V = \frac{kQ}{r}$. Here r is the distance from the point charge to the observer's location (point P). In this problem, we have $r = 30.0cm - 5.00cm = 25.0cm$. Thus, the electric potential at the point P is $V = \frac{(8.99 \times 10^9)(33.0 \times 10^{-9})}{0.250} = 1190$V.

P14. (C) A charged particle in a magnetic field will trace out a circle with a radius given by $r = \frac{mv}{QB}$. From the given values, we first find the radius: $r = \frac{26.0}{2} = 13.0cm = 0.130$m, and we convert the magnetic field into the proper units: $B = 450G = 0.0450T$. Now, using the mass and charge of a proton, and plugging in the given values we obtain $r = 0.130 = \frac{(1.67265 \times 10^{-27})v}{(1.602 \times 10^{-19})(0.0450)} \;\rightarrow$ $0.130 = (2.32 \times 10^{-7})v$. This gives a velocity for the proton of $v = 5.60 \times 10^5$ m/s.

P15. (B) We'll use $\Phi_B = BA\cos\theta$ to find the initial magnetic flux passing through the loop of wire. Here the angle θ is measured from the normal line of the area of the loop (that is from a line that is perpendicular to the face of the loop). Since the magnetic field is perpendicular to the face of the loop, the magnetic field and the normal line are in the same direction. Thus, $\theta = 0°$. We also need the area of the loop. The loop is rectangular, so the area is found using $A = lw = (0.300)(0.150) = 0.045$m^2. Converting the field strength into proper units, we find that the initial magnetic flux is $\Phi_{Bi} = B_i A\cos\theta = (0.0220T)(0.045m^2)\cos 0° = 9.90 \times 10^{-4}\ Tm^2$. The final magnetic flux is zero since $B_f = 0 \;\rightarrow\; \Phi_{Bf} = 0$. Now we use Faraday's Law to determine the voltage (EMF) induced in the loop by the changing magnetic flux: $\mathcal{E} = -\frac{\Delta\Phi_B}{\Delta t} = -\frac{0 - 9.90 \times 10^{-4}\ Tm^2}{62.0 \times 10^{-6}\ s} = 15.97\ V$. Finally, we use Ohm's Law to find the current induced in the loop: $\mathcal{E} = IR \;\rightarrow\; 15.97V = I(1.20\Omega) \;\rightarrow\; I = 13.3\ A$.

P16. (E) The focal length of the mirror is $f = \frac{R}{2} = \frac{200.0}{2} = 100.0cm$. Since the mirror is concave, the focal length is positive. Now, working entirely in centimeters, we find the location of the image of the moth: $\frac{1}{p} + \frac{1}{q} = \frac{1}{f} \rightarrow \frac{1}{56.0cm} + \frac{1}{q} = \frac{1}{100.0cm} \rightarrow q = -127.3cm$. Since the image location is negative, we know that the image is virtual. The magnification of the image is given by $M = -\frac{q}{p} = -\frac{-127.3cm}{56.0cm} = 2.27$. The magnification is positive, so the image is upright. The size of the wingspan of the image of the moth is then: $w' = Mw = (2.27)(5.00cm) = 11.4cm$.

P17. (E) First, we need to find the energy (in eV) of the photons of light. To do this, we use $E_\gamma = \frac{1240\ eVnm}{\lambda} = \frac{1240\ eVnm}{455\ nm} = 2.725eV$. Then we use the photoelectric effect equation to find the energy imparted to each electron as kinetic energy: $KE = E_\gamma - \phi = 2.725 - 2.28 = 0.445eV$. This energy is low enough that the electrons will not move at relativistic speeds. Thus, we can use the classical equation for the kinetic energy: $KE = \frac{1}{2}mv^2$. Converting the kinetic energy into Joules and putting in the mass of an electron gives: $KE = 0.445eV(1.602 \times 10^{-19}) = 7.13 \times 10^{-20}J = (0.5)(9.11 \times 10^{-31}kg)v^2 \rightarrow v^2 = 1.57 \times 10^{11}$. This gives an emitted electron velocity of $v = 3.96 \times 10^5$ m/s.

P18. (A) This radioactive decay chain involves the emission of three alpha particles, two negative beta particles, and two gamma rays. Alpha particles carry away four units of mass and two units of positive charge. Negative beta particles carry no units of mass but take away one unit of negative charge. Gamma rays carry neither mass nor charge (only energy). Based on this, the mass number of the daughter isotope will be:
$M = 285 - 3\alpha - 2\beta^- - 2\gamma = 285 - 3(4) - 2(0) - 2(0) = 285 - 12 = 273$. And the charge (proton number) of the daughter isotope will be:
$Z_d = 112 - 3\alpha - 2\beta^- - 2\gamma = 112 - 3(2) - 2(-1) - 2(0) = 112 - 6 + 2 = 108$. Thus, the daughter isotope will have a mass of 273 and a proton number of 108, which means that it is $^{273}_{108}Hs$.

P19. (C) On a plot of velocity versus time, the acceleration is equal to the slope of the line. To find the slope, I'll choose two points on the line that aren't data points – specifically, I'll use (1.3s, 30.0m/s) and (7.0s, 10.0m/s). The slope (and the acceleration) is then:
$slope = \frac{y_2 - y_1}{x_2 - x_1} = \frac{10.0 - 30.0}{7.0 - 1.3} = \frac{-20.0m/s}{5.7s} = -3.5$ m/s$^2 = acceleration$.

P20. (D) The important equation for this problem is Ohm's Law: $V = IR$. These data do not trace out a straight line, so we will use a single point on the curve to estimate the voltage. I'll choose the point (33.0Ω, 2.0A). Plugging these values into Ohm's Law gives $V = (2.0A)(33.0\Omega) = 66\ V \approx 65\ V$.