University Interscholastic League

*Making a World of Difference*

# CURRENT ISSUES & EVENTS

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## 2024 • STATE

May 12, 2024


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UNIVERSITY INTERSCHOLASTIC LEAGUE

# CURRENT ISSUES & EVENTS

## STATE • 2024

1. **Saying the legislation violates constitutional protections of free speech, TikTok is suing the U.S. government to stop enforcement of a bill passed last month that seeks to do what?**
   a. force ByteDance to store data from U.S. citizens on servers located in the U.S.
   b. force ByteDance to sell TikTok
   c. require ByteDance to make the code for the software open to all programmers
   d. require ByteDance to ban the software from use by Chinese citizens

2. **More than 60 House Republicans, led by Speaker Mike Johnson, visited Eagle Pass, Texas, in January. They threatened to starve the entire federal government of funding. What were the Republicans demanding?**
   a. $75 million for the war in Ukraine
   b. $1.2 million to crack down on the trafficking of dangerous drugs like fentanyl across the southwest border
   c. a crackdown at the U.S.-Mexico border to choke off the flow of migrants streaming into the country
   d. making student-led prayer and religious expression in public schools legal in all 50 states

3. **For the first time ever, the Environmental Protection Agency said it is issuing a national regulation limiting the amount of what chemicals found in drinking water?**
   a. certain per- and polyfluoroalkyl substances
   b. lead and cadmium
   c. phthalates and bisphenols
   d. hydrochlorofluorocarbons

4. **The ship's crew sent out a mayday signal. The transportation authority police officers stopped traffic. Together, these actions helped to avert an even greater catastrophe. Where?**
   a. Lake Ontario Bridge in Toronto
   b. Interstate 35 bridge over the Mississippi River in Minneapolis
   c. Fishing Wars Memorial Bridge, Tacoma, Washington
   d. Francis Scott Key bridge in Baltimore

5. **Oprah Winfrey said in late February she was stepping down from what board after more than a decade, causing stock in the company to fall 25%?**
   a. Harpo Productions
   b. Tennessee State University
   c. WeightWatchers
   d. Oprah's Angel Network

6. **The fire became the largest on record in the state's history, scorching more than a million acres, devastating cattle ranches and consuming homes. Never before had anyone seen a fire quite like the Smokehouse Creek fire. Where?**
   a. Maine and New Brunswick, Canada
   b. Mendocino County, California
   c. Eastern Alaska
   d. The Texas Panhandle

7. **Although it cost billions more than anticipated and took years longer than originally projected, Plant Vogtle Unit 4 came online in Georgia this spring. Designed to power 500,000 homes and businesses without releasing any carbon, what type of power plant is it?**
   a. hydroelectric
   b. nuclear
   c. solar
   d. wind

8. **U.S. President Joe Biden signed a $95.3 billion aid package, sending military aid to all of the following countries EXCEPT which one of the following?**
   a. Ukraine
   b. Taiwan
   c. Israel
   d. Mexico

9. **Marcia L. Fudge was only the second Cabinet secretary to leave U.S. President Joe Biden's administration. What agency did Fudge lead?**
   a. Labor
   b. Housing and Urban Development
   c. Transportation
   d. Education

10. **When the stamps were introduced in 2007, they cost 41 cents. In the fifth price increase in two years, the U.S. Postal Service raised the price of Forever stamps Jan. 21 to what?**
    a. 68 cents
    b. 63 cents
    c. $1.12
    d. $1.36

11. **High school students began taking a revamped version of the SAT in March, a version designed to reduce stress, according to the College Board. What's new about it?**
    a. It's longer, 3 hours instead of 2 hours and 14 minutes.
    b. The reading passage is longer.
    c. It's fully digital.
    d. Test-takers can no longer use an online graphing calculator during the math section.

12. **Mitch McConnell acknowledged that his views are out of step from the views of other Republicans. He plans to complete his full Senate term ending in 2027, but he said he plans to step down from what other role that he's held for about 17 years?**
    a. vice president
    b. Senate president pro tempore
    c. chair of the Republican National Committee
    d. Senate Republican leader

13. **Former President Donald Trump hawked Trump-branded sneakers at Sneaker Con, a gathering that bills itself as the "The Greatest Sneaker Show on Earth." Why did artist officials with the luxury brand Christian Louboutin take issue with the sale of the gold high tops with red soles?**
    a. Louboutin, an ardent Democrat, owns the patent to the process used to paint the shoes gold
    b. Louboutin has copyright on men's running shoes painted in patriotic colors such as red, white, blue and gold
    c. As the inventor of men's athletic high-tops, Louboutin wants the royalties Trump didn't pay
    d. Louboutin has a trademark on iconic red soles

**14. Major technology companies signed a pact in mid-February to adopt "reasonable precautions" to do what?**

a. prevent AI tools from being used to disrupt elections around the world
b. remove "fake news" from their sites
c. build in spell-checkers and grammar-checkers that will, without human intervention, correct basic problems
d. block people under the age of 18 from signing on to social media

**15. The U.S. economy grew faster than any other G7 economy in 2023 and is on track to do so again in 2024. But which G7 country was the only one to have negative estimated gross domestic product for 2023?**

a. France
b. Germany
c. Japan
d. United Kingdom

**16. Over 200 million people are diagnosed annually. Roughly 600,000 die as a result, nearly 80% of them children. To combat this disease, Cameroon became the first country to start routinely vaccinating children for what?**

a. malaria
b. Ebola
c. rabies
d. dysentery

**17. Robert F. Kennedy Jr., who is running for president as an independent, announced that he had filed paperwork to create his own political party in an effort to get his name on the ballot in California, Delaware, Hawaii, Mississippi and North Carolina. What party?**

a. New Camelot party
b. We the People party
c. New Deal coalition
d. Post-Truth in Politics party

**18. "These coins embody her spirit, her perseverance, her tireless efforts and her desire for freedom for all individuals," said U.S. Mint Director Ventris Gibson. The U.S. Mint released $5 gold coins, $1 silver coins and half-dollar coins to commemorate the bicentennial of whose birth?**

a. Mary Ann Shadd, journalist
b. Harriet Tubman, an American abolitionist
c. Clara Barton, founder, American Red Cross
d. Susan B. Anthony, campaigner for women's rights

**19. The Agriculture Department announced in April that it had finalized the regulation it had first proposed in February 2023 that made what changes to school meals?**

a. School meals will contain less salt and sugar.
b. School meals will not contain chocolate (or other flavored) milk.
c. School meals will be free to everyone enrolled in a public school.
d. Any and all breads and bread products in school meals will be made of whole grains.

**20. Taylor Swift's new album, 31 tracks, "The Tortured Poets Department," broke what record?**

a. It was Spotify's most-streamed in a single day – more than 300 million streams.
b. Swift became the first female solo artist to top country music charts.
c. After this album, Swift, 20, became the youngest artist to win the Grammy Award for Album of the Year.
d. The black-and-white music video for one of the songs, "I Hate It Here," achieved the highest female and solo 24-hour debut for a music video on YouTube with 65.2 million views.

**21. Similar to measures passed in Utah and Arkansas, Florida Gov. Ron DeSantis signed a law, SB3, banning children under age 14 from having access to which of the following after Jan. 1, 2025?**

a. certain library books
b. social media
c. vaping products
d. mifepristone

**22. For the first time in 27 years, the U.S. government changed how it categorizes people by race and ethnicity, an effort that federal officials believe will more accurately count some populations. What change was made?**

a. A Middle Eastern and North African category will be removed from the choices available for questions about race and ethnicity.
b. Questions about race and ethnicity that previously were asked separately on forms will be combined into a single question so respondents can pick multiple categories at the same time.
c. The words "Alaska Natives" and "Genetic admixture" will be added as more specific adjectives.
d. The revisions discourage the collection of detailed race and ethnicity data beyond the minimum standards, such as "Haitian" or "Jamaican" for someone who checks "Black."

**23. For the first time in the 12 years of a report by Gallup, the U.S. dropped out of the top 20 on the list of happiest countries, now ranking at No. 23. What country topped the list?**

a. Germany, which was No. 15 last year
b. Iceland, for three of the last five years
c. Finland, for the seventh year straight
d. Afghanistan, for the first year

**24. Shareholders of Digital World Acquisition Corp. approved a deal to merge with the former U.S. President Donald Trump's media business. As a result, Trump Media & Technology Group will be traded on the Nasdaq stock market, possibly netting Trump billions of dollars. What is the Group's flagship product?**

a. TikTok
b. WhatsApp
c. WeChat
d. TruthSocial

**25. Russian President Vladimir Putin vowed to fulfill Moscow's goals in Ukraine and sternly warned the West against deeper involvement in the fighting. Specifically, what did he warn of?**

a. a nuclear conflict that will mean the destruction of our civilization
b. the demise of the world's bread basket and the resulting death of millions
c. closure of the Suez Canal and an end to affordable oil from the Middle East
d. creation of nuclear weapons by Iran, Iraq, Syria and North Korea

**26. Although the effort failed, it was the closest the Texas Nationalist Movement has come in nearly two decades of trying to put what on the ballot for a vote?**

a. an independent candidate for president
b. the legalization of marijuana
c. school vouchers
d. Texit — Texas seceding from the U.S.

**27. Normally, it's home to some 280,000 residents. Because the population swelled to more than 1.5 million people, Benjamin Netanyahu ordered his military to develop evacuation plans before any assault on what city?**

a. Rafah
b. Gaza
c. Damascus
d. Suez

**28. The special counsel report found evidence that U.S. President Joe Biden willfully retained and shared classified information when he was a private citizen but concluded criminal charges were not warranted. The report from special counsel Robert Hur also said what?**

a. "In this two-tiered system of justice, the president is above the law."
b. He considered the case on the same merits as Trump's case, which is why they have similar outcomes.
c. Biden is a "a sympathetic, well-meaning, elderly man with a poor memory."
d. "I'm not charging Biden, and Trump should not be charged."

**29. Just a day after he was sentenced to a decade in prison, former Prime Minister Imran Khan was ordered jailed for 14 years in a separate case, dealing him another heavy blow in his bitter feud with the country's powerful military. Khan was prime minister of what country?**

a. Tajikistan
b. India
c. Pakistan
d. Bangladesh

**30. China's population stood at 1.4 billion in 2023. How did that compare to previous years?**

a. The population has been very steady at 1.4 billion thanks to the one-child policy.
b. China became the most populous country in the world, beating out India.
c. The population fell because of the 11.1 million people who died there of COVID-19.
d. The population fell for the second straight year. The birth rate decreased, and the death rate increased.

**31. According to a study published in *JAMA Pediatrics* in late April, what did scientists find may protect against developing depressive symptoms, anxiety and attention deficit hyperactivity disorder in children and adolescents?**

a. cutting social media use
b. having an imaginary friend
c. physical activity
d. avoiding popular, and violent, computer games such as Mortal Kombat

**32. In 2020, Zillow said prospective homebuyers would need to make $59,000 to be able to buy a typical home in the United States. This year, Zillow and Bankrate both predicted prospective homebuyers would need to be making how much money per year for the same home?**

a. more than $106,000
b. about the same amount, $60,000
c. about 3.2% more, same as the rate of inflation, $71,874
d. $402,343

**33. The Justice Department said it had recommended easing restrictions on marijuana in what could amount to a major change in federal policy. What change?**

a. It ends the criminalization of the drug.
b. It moves the drug from Schedule III to Schedule I.
c. It liberalizes marijuana policy, meaning it could be prescribed by a doctor.
d. It defines the drug as having no medical use.

**34. Arizona Gov. Katie Hobbs vetoed House Bill 2793 that sought to do what for all students at public schools across the state?**

a. block all social media sites on school-provided internet during school hours
b. limit cellphone use
c. provide free breakfast and lunch
d. give students access to free mental health care

**35. Instagram says it's deploying new tools to protect young people, including a feature that will automatically do what?**

a. detect their ages and block underage users
b. use biometrics to determine their identity and then ask their parents if use of social media is permitted
c. remove any personally identifying data from public posts
d. blur nudity in direct messages

**36. The Israel-Hamas war has tested free speech policies at universities in Texas and across the country. What action did Gov. Greg Abbott take regarding "the sharp rise in antisemitic speech and acts on university campuses"?**

a. He called the Legislature back into special session to deal with related issues.
b. He passed a law making antisemitic speech a "hate crime."
c. He issued an executive order requiring schools to discipline such speech.
d. He called for voters to remove from office any politicians who supported Israel.

**37. The retailer's family of brands has struggled as inflation impacts its low-income shoppers' wallets. What company, therefore, plans to close hundreds of its stores nationwide?**

a. Dollar Tree
b. Walmart
c. Target
d. Kmart

**38. To win the election as president, Taiwan's vice president, Lai Ching-te, whose party has emphasized the island's sovereignty, defeated an opposition party that favors reviving engagement with what country?**

a. Russia
b. China
c. Ukraine
d. North Korea

39. **France, Jordan, the United Kingdom and the United States helped to intercept nearly all of the some 170 drones, 30 cruise missiles and 120 ballistic missiles that what country fired toward Israeli territory in mid-April?**
    a. Yemen
    b. United Arab Emirates
    c. Iran
    d. Bahrain

40. **U.S. President Joe Biden awarded $8.5 billion in grants to Intel during a tour of battleground states meant to sell his economic agenda. For what?**
    a. to refund the cost of higher education for those in the computer industry
    b. to develop an online system for artificial intelligence-based medical care
    c. to block fake news from being distributed on social media
    d. to bolster the nation's semiconductor production

**THE ESSAY**

**NOTE: *Contestants who do not write an essay will be disqualified*. Essay length is not a major grading factor as long as the essay is substantial and demonstrates a sincere effort to discuss the assigned topic. Cover as many corners of the issue as practical, including historical, political, economic, social and cultural, when relevant. Avoid including your personal opinions, as more than enough information on the subject has been published.**

**A focused, concise and specific essay beats a vague and rambling essay.**

**PROMPT**

Climate change is "the most important story, probably, on Earth," according to Claudia Dreifus, an instructor in Columbia University's master's in sustainability management program, "and yet very difficult to report on." Still, there has been plenty of news regarding climate change in the last year.

According to the Environmental Protection Agency, most of Texas has warmed between one-half and one degree Fahrenheit in the past century. In the eastern two-thirds of the state, average annual rainfall is increasing, yet the soil is becoming drier. Rainstorms are becoming more intense, and floods are becoming more severe. Texas leads the nation in both the most frequent severe weather events and the most expensive weather events, accounting for 15% of all U.S. billion-dollar disasters, according to NOAA. From 1980 to 2024, Texas experienced 171 billion-dollar climate disaster events. As Houston meteorologist Daji Aswad wrote, "[Climate change] can be seen and felt across our community."

Discuss some impacts of climate change in 2024 on the United States generally and some on Texas specifically, including, but not limited to, impacts on the environment, economy, agriculture, energy, political system and/or society.

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# UIL HIGH SCHOOL SCIENCE CONTEST
# ANSWER KEY
# 2024 STATE

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

**CHEMISTRY SOLUTIONS – UIL STATE 2024**

C01. (E) First calculate how many moles of gas are in the balloon. Half of the moles are helium (molar mass 4.00 g/mol) and half of the moles are argon (39.95 g/mol). Determine the mass of the helium, the mass of the argon, and add that to the mass of the empty balloon, then divide by the volume to get density.

*PV* = *nRT*, so *n* = *PV*/*RT* = (1·14.5)/(0.08206·298) = 0.59295 moles.
Moles of each gas = 0.29648 mol.
Mass of helium = 0.29648 mol × 4.00 g/mol = 1.1859 g.
Mass of argon = 0.29648 mol × 39.95 g/mol = 11.8442 g.
Total mass of inflated balloon = 1.1859 + 11.8442 + 39.2 = 52.23 grams.
Density = mass/volume = 52.23 g/14.5 L = 3.30 g/L

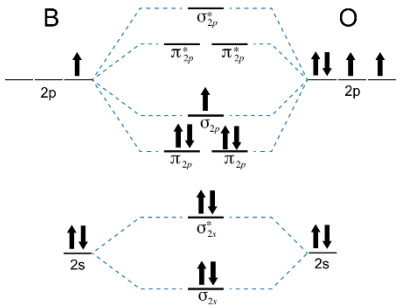
C02. (A) Calculate moles of $SF_4$ and moles of $F_2$. They will react according to the equation $SF_4(g) + F_2(g) \rightarrow SF_6(g)$ until one of them runs out. The total moles of gas in the sample will then be the moles of $SF_4$ formed plus the moles of the excess reactant.

Moles of $SF_4$ = $7.70 \times 10^{24} / 6.02 \times 10^{23}$ = 12.791 mol $SF_4$. Moles of $F_2$ = 770 g / 38 g/mol = 20.263 mol $F_2$. The $SF_4$ will run out first, producing 12.791 mol $SF_6$ and leaving an excess of 7.4725 moles of $F_2$. The total moles of gas at the end of the reaction is 12.790 + 7.4725 = 20.263 mol.
*V* = *nRT*/*P* = (20.263)(0.08206)(298)/1 = 496 L

C03. (B) N-14 has 7 protons and 7 neutrons. C-14 has 8 neutrons, and the others each have 10.

C04. (D) Initial gas moles: *n* = *PV*/*RT* = (1.0)(10.0)/(0.08296)(298.6) = 0.4081 moles
Final gas moles: *n* = *PV*/*RT* = (2.5)(25.0)/(0.08296)(347.4) = 2.1924 moles
Moles added = 2.1924 – 0.4081 = 1.7843 moles. 50.0 g/1.7843 mol = 28.02 g/mol, which is $N_2$.

C05. (E) The total number of valence electrons in B–O is 6 + 3 = 9. There are 7 electrons in bonding orbitals and 2 electrons in anti-bonding orbitals, so the bond order is (7 – 2)/2 = 2½.




C06. (B) Lattice energy depends on the magnitude of the ionic charges and the size of the ions. Higher charges and smaller ionic radii result in a higher the lattice energy. Answer choices A, B, and D all have ions with charges of 1 and 3 (the signs don't matter), whereas C and E only have charges of 1 and 2, so to break the tie among A, B, and D you look at the ion size. A and D both have large polyatomic –3 anions, whereas B has a much smaller hydroxide ion along with a very small $Cr^{3+}$ ion, so $Cr(OH)_3$ will have the strongest attractions between the ions and therefore the highest lattice energy.

C07. (D) $\Delta U = q + w$ $q = mc\Delta T$ and $w = -P\Delta V$. $m$ = 125 g, $c$ = 4.184 J/c°C, $\Delta T$ = 3.6°C.
$q$ = (125)(4.184)(3.6) = 1882.8 J, but heat is given off so this has to be negative: $q$ = –1882.8 J
$w = -P\Delta V$ = –(1 atm)(0.525 L –1.025 L) = 0.500 L·atm. 0.500 L·atm × 101.325 J/L·atm = 50.66 J
$\Delta U = q + w$ = –1882.8 J + 50.66 J = –1832 J

C08. (A) $\Pi V = nRT = (g/MM)\cdot RT$, so g = $\Pi V \cdot MM/RT$. Π = 3.33 atm, $V$ = 1.500 L, $T$ = 288K, $R$ = 0.08206L·atm/mol·K,. The molar mass of $BaCl_2$ is 208.23 g/mol. Plug the numbers in and $g$ = 44.01 g

C09. (C) Equilibrium constants have an exponential dependence on temperature, so $K$ and $T$ are related by the van't Hoff equation.

$$\ln\left(\frac{K_2}{K_1}\right) = \frac{\Delta H_{\text{rxn}}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$K_2$ = 500, $K_1$ = 3095, $T_1$ = 298 K, $T_2$ = ? K, $\Delta H_{\text{rxn}}$ = –30,400 J, $R$ = 8.314 J/mol·K

$$\ln\left(\frac{500}{3095}\right) = \frac{-30400}{8.314}\left(\frac{1}{298} - \frac{1}{T_2}\right)$$

$T_2$ = 350.0 K = 77°C

C10. (A) Since it is a weak base in solution, assume $K_b$ is small and the answer will be found somewhere in the equation $[OH^-] = \sqrt{K_b C_{\text{base}}}$ . If we know $K_b$ we can solve for $K_a$ using $K_a \times K_b = K_w$

At pH 9.67 $[OH^-] = 4.677\times10^{-5}$ M. $C_{base} = (g/MM)/V = (5.00/144.11)/0.250 = 0.13878$ M
$K_b = [OH^-]^2/C_{base} = 1.5762 \times 10^{-8}$. $K_b$ is in fact very small, so our initial assumption is good.
Therefore $K_a = 1 \times 10^{-14} / 1.5762 \times 10^{-8} = 6.34 \times 10^{-7}$.

C11. (D) $K_{sp}$ for $Ni(OH)_2$ is $2.8 \times 10^{-16} = [Ni^{2+}][OH^-]^2$. $[OH^-]^2 = 2.8 \times 10^{-16}/0.010 = 2.8 \times 10^{-14}$, so $[OH^-] = 1.67 \times 10^{-7}$. pOH = 6.78 and pH = 7.22

C12. (C) The skeletal equation is $ClO^-(aq) + OH^-(aq) \rightarrow Cl^-(aq) + O_2(g)$

The unbalanced half reactions are $ClO^- \rightarrow Cl^-$ and $OH^- \rightarrow O_2$
When balanced in basic solution the half-reactions are $ClO^- + H_2O + 2e^- \rightarrow Cl^- + 2OH^-$ and $4OH^- \rightarrow O_2 + 2H_2O + 4e^-$ Double the reduction half-reaction to equalize the electrons and then add, and the overall balanced net ionic equation becomes

$2ClO^- + 2H_2O + 4e^- \rightarrow 2Cl^- + 4OH^-$
$\underline{4OH^- \rightarrow O_2 + 2H_2O + 4e^-}$
$2ClO^- \rightarrow O_2 + 2Cl^-$

The charge on each side of the balanced overall net ionic equation is –2. (Yes, one of the reactants is not in the net ionic equation! $OH^-$ is still a reactant and is not a catalyst because the product $O_2$ comes from the $OH^-$ reactant. A catalyst comes out of a reaction unchanged.)

C13. (E) Rate constants, and by extension reaction rates, have an exponential dependence on temperature, with the activation energy as part of the equation. The Arrhenius equation is used to solve this. Since the reaction rate is proportional to the rate constant, you can use the ratio of reaction rates in place of the ratio of rate constants.

$$\ln\left(\frac{k_2}{k_1}\right) = \ln\left(\frac{rate_2}{rate_1}\right) = \frac{E_a}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$rate_2/rate_1 = 2$, $R = 8.314$ J/mol·K, $T_1 = 293$ K, $T_2 = 308.7$ K

$$\ln(2) = \frac{E_a}{8.314}\left(\frac{1}{293} - \frac{1}{308.7}\right)$$

Solving for $E_a$, $E_a = 33200$ J = 33.2 kJ

C14. (B) The formula for copper(II) sulfate pentahydrate is $CuSO_4 \cdot 5H_2O$. The overall molar mass of the compound is 249.72 g/mol and the molar mass of Cu is 63.55 g/mol, so the mass of copper in 500 grams of the compound is (63.55/249.72) × 500 g = 127 g

C15. (A) $KE = h\nu - \varphi = hc/\lambda - \varphi$. $\lambda = hc/(KE + \varphi)$ $h = 6.626 \times 10^{-34}$ J·s, $c = 3.0 \times 10^8$ m/s,
$\varphi = 2.3$ eV × $(1.602 \times 10^{-19}$ J/eV) = $3.6846 \times 10^{-19}$ J
$KE = \frac{1}{2}mv^2 = \frac{1}{2}(9.11 \times 10^{-31}$ kg)( $8.28 \times 10^5$ m/s)$^2 = 3.1228 \times 10^{-19}$ J
$\lambda = (6.626 \times 10^{-34})(3.0 \times 10^8)/(3.1228 \times 10^{-19} + 3.6846 \times 10^{-19}) = 2.92 \times 10^{-7}$ m = 292 nm

C16. (D)

| Species | $V(CO)_6$ | $VO_4^{3-}$ | $VO_2$ | $VO(O_2)(H_2O)_4^+$ | $VO_2^-$ |
|---|---|---|---|---|---|
| V oxidation number | 0 | +5 | +4 | +3 | +3 |

C17. (E) This is a stoichiometry problem relating the heat of the reaction to the moles of $CO_2$ produced. The balanced equation is $CH_3COOH + NaHCO_3 \rightarrow CH_3COONa + H_2O + CO_2(g)$
$\Delta H = 43{,}600$ J/mol

The heat lost by the surroundings is $q = mc\Delta T = (500)(4.184)(20.7 - 23.5) = -5857.6$ J. so the heat absorbed by the reaction is 5857.6 J.

5857.6 J × (1 mol $CO_2$ / 43,600 J) = 0.13432 moles $CO_2$ produced.
$V = nRT/P = (0.13432)(0.08206)(296.8)/1$ atm = 3.27 L

C18. (A) The lab assistant has made up a 6 *molal* solution (6 mol solute per 1 kg solvent), not a 6 *molar* solution (6 moles of solute in 1 L of solution). To know the molarity you need to figure out how many liters of solution this is. The entire solution has a mass equal to the mass of the NaCl plus the mass of the water. 6 moles × 58.44 g/mol = 350.64 grams NaCl. The density of water on the data sheet is given as 1.00 g/mL, so the mass of solvent is 1000 g. 350.64 g + 1000 g = 1350.64 g of solution. From the density of the solution, 1350.64g / 1.194 g/mL = 1131.19 mL = 1.13119 L.
6 mol / 1.13119 L = 5.30 M

C19. (C) Molecular orbital theory does not use atomic orbitals with names like *s* and *p*, and instead uses molecular orbitals with names like σ, σ*, π, and π*. *s* orbitals can only form σ and σ* molecular orbitals, and atomic *p* orbitals can form σ, σ*, π, and π* molecular orbitals. So answer choices D and E that are π* and π molecular orbitals derived from atomic *s* orbitals are impossible.

C20. (B) Vapor pressure has an exponential dependence on temperature, so use the Clausius-Clapeyron equation to solve this. The heat of vaporization for water is on the data page as 2260 J/g, so multiply that by 18.02 to get $\Delta H_{vap}$ in J/mol. 2260 J/g × 18.02 g/mol = 40,725 J/mol.

$$\ln\left(\frac{P_2}{P_1}\right) = \frac{\Delta H_{\text{vap}}}{R}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$$

$P_2$ = ?, $P_1$ = 0.0313 , $\Delta H_{vap}$ = 40,725 J/mol, $R$ = 8.314 J/mol·K, $T_1$ = 298 K, $T_2$ = 273 K

$$\ln\left(\frac{P_2}{0.0313}\right) = \frac{40{,}725}{8.314}\left(\frac{1}{298} - \frac{1}{273}\right)$$

$P_2$ comes out to be 0.00695 atm × 760 torr/atm = 5.28 torr.

**PHYSICS SOLUTIONS – UIL STATE 2024**

P01. (D) page 223: "…he had learned far more from his books than from his militaristic teachers at school. During his first year at Luitpold, for example, Einstein cuddled up to *Popular Books on Physical Sciences*, an engaging collection of volumes written by one Aaron Bernstein."

P02. (C) page 239: "Maxwell leapt to the conclusion that his hypothetic electromagnetic ripples and Young's light waves had to be one and the same thing. In 1888, Maxwell's mathematical conjecture was confirmed when German physicist Heinrich Hertz used a giant spark generator to produce an effusion of electromagnetic waves."

P03. (B) page 250: "This meant for a person travelling at the speed of light… the person's mass and energy appeared to expand up to infinity…. He interpreted these outrageous predictions to mean that his new theory was trying to tell him something, namely that it was physically impossible for any material body to travel as fast as an electromagnetic wave…"

P04. (B) From the HR diagram, an average F-class star has an absolute magnitude of about $M = +4$. We are given the apparent magnitude of $m = +10.5$. The distance to the star can then be calculated using $d = 10 \times 10^{(m-M)/5} = 10 \times 10^{(10.5-4)/5} = 10 \times 10^{1.3} = 200$parsec. Converting to light years, we get $d = 200parsec * 3.26 = 650 \approx 700$ light years.

P05. (A) The units of $\varepsilon_0$ are $C^2/Nm^2$ and the units of $\mu_0$ are $Tm/A$ as given in the table of constants. Recall a few conversions: $1\ A = 1\ C/s$ and $1\ T = 1\ kg/Cs$. Multiplying this all together, we get $\varepsilon_0\mu_0 \rightarrow \frac{TmC^2}{ANm^2}$. Putting in the conversions: $\frac{TmC^2}{ANm^2} \rightarrow \frac{kgmC^2s}{CsCNm^2} \rightarrow \frac{kg}{Nm}$. Finally, recall that $1\ N = 1\frac{kgm}{s^2}$. This leads to $\varepsilon_0\mu_0 \rightarrow \frac{kg}{Nm} \rightarrow \frac{kgs^2}{kgmm} \rightarrow \frac{s^2}{m^2}$. Thus, the quantity $Z = \sqrt{\varepsilon_0\mu_0}$ has units of $\sqrt{\frac{s^2}{m^2}} = \frac{s}{m}$.

P06. (D) Find initial velocity components: $v_{ix} = v_i \cos\theta = (16.0)\cos(56.0) = 8.95m/s$, and $v_{iy} = v_i \sin\theta = (16.0)\sin(56.0) = 13.26m/s$. Find the time to reach the building: $x = x_i + v_{ix}t \rightarrow 15.0m = (8.95)t \rightarrow t = 1.677s$. Find the height of impact on the building: $y = y_i + v_{iy}t + \frac{1}{2}a_yt^2 \rightarrow y = 2 + (13.26)(1.68) + (0.5)(-9.80)(1.68)^2 = 10.466m$. Find the vertical velocity at the time of impact with the building: $v_y = v_{iy} + a_yt = 13.26 - 9.80(1.677) = -3.165m/s$. Since the speed and angle stay the same after bouncing from the building, the vertical velocity remains the same. The horizontal velocity stays the same magnitude but reverses sign. That is, after bouncing, we have $v_{x2} = -8.95m/s$ and $v_{y2} = -3.165m/s$. We are also located at the point $x_2 = 15.0m$ and $y_2 = 10.465m$. Now we find the time needed to reach the ground from the point of impact: $y_f = y_2 + v_{y2}T + \frac{1}{2}a_yT^2 \rightarrow 0 = 10.466 - 3.165T + (0.5)(-9.80)T^2 \rightarrow 4.90T^2 + 3.165T - 10.466 = 0$. Solving the quadratic gives: $T = 1.17s, -1.82s$. We ignore the negative result, so $T = 1.17s$. Finally, we find the horizontal location when the ball hits the ground: $x_f = x_2 + v_{x2}T = 15.0 + (-8.95)(1.17) = 4.50m$. This is the distance from you to the place where the ball hits the ground.

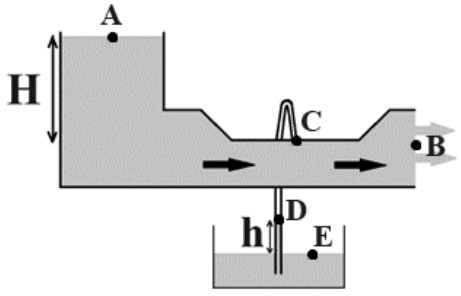
P07. (C) The forces acting on the 5.00kg mass are Tension (T, upward) and gravity ($m_1 g$, downward). We treat the moveable pulley and the 6.00kg mass as a single unit since they are fixed together. The forces acting on the moveable pulley-6.00kg mass unit are two tensions, one for the rope on each side (2T, upward), and gravity ($m_2 g$, downward). This simple block-and-tackle system gives a mechanical advantage, but also results in the moveable pulley-6.00kg mass unit moving at half the rate of the 5.00kg mass. Thus, if the acceleration of the 5.00kg mass is $a$, then the acceleration of the moveable pulley-6.00kg mass unit is only $\frac{1}{2}a$. Now we can use Newton's second law. For the 5.00kg mass: $\sum F = T - m_1 g = m_1(-a)$. The acceleration is negative since the mass is falling downward. This gives: $T - (5.00)(9.80) = -5.00a \;\rightarrow\; T = 49.0 - 5.00a$. For the moveable pulley-6.00kg mass unit, we get: $\sum F = 2T - m_2 g = m_2\left(\frac{1}{2}a\right)$. The acceleration is half as much, but it is positive since this unit is moving upward. This gives: $2T - (6.00)(9.80) = (6.00)(0.5)a \;\rightarrow$ $2T - 58.8 = 3.00a$. Plugging the result from the first equation into this second equation, we get: $2(49.0 - 5.00a) - 58.8 = 3.00a \;\rightarrow\; 98.0 - 10.0a - 58.8 = 3.00a \;\rightarrow\; 39.2 = 13.0a$. Thus, the acceleration of the 5.00kg mass is $a = 3.02 m/s^2$.

P08. (B) The mass of the box really doesn't matter – what matters is the force. Work is defined as $W = \int F \cdot dr$. Since this problem takes place in one dimension, we don't need to worry about the dot product: $W = \int F dx$. Putting in the force equation and the starting and ending points, we have $W = \int_0^6 (72 - 2x^2)dx = \left(72x - \frac{2}{3}x^3\right)\Big|_0^6 = 72(6) - \frac{2}{3}(6)^3 - 0 + 0 = 432 - 144 = 288$ J.

P09. (E) The inertia of the merry-go-round is $I_{disk} = \frac{1}{2}(55.0)(1.44)^2 = 57.0$ kgm$^2$. Initially, the person standing at the exact center of the merry-go-round does not contribute to the inertia of the system. Thus $I_0 = I_{disk} = 57.0$ kgm$^2$. After walking to the edge, the person contributes to the inertia with an additional $I_{person} = Mr^2 = (80.0)(1.44)^2 = 166$ kgm$^2$. This gives a total final inertia for the system of $I_f = I_{disk} + I_{person} = 57.0 + 166 = 223$ kgm$^2$. Rotational momentum is conserved, so we have $L_0 = L_f \;\rightarrow\; I_0\omega_0 = I_f\omega_f \;\rightarrow\; (57.0)(32.0) = (223)\omega_f \;\rightarrow\; \omega_f = 8.18\, rad/s$.

P10. (A) For an open-closed pipe, the frequencies are $f = \frac{nv}{4L}$ where n is an odd integer. One harmonic above the fundamental would be $n = 3$. Now we can get the speed of sound: $652 = \frac{3v}{4(0.37)} \;\rightarrow$ $v = 321.7$m/s. From this we can use: $v(T) = (331 m/s)\sqrt{T/273}$ where T is temperature in Kelvin. From this: $321.7 = 331\sqrt{T/273} \;\rightarrow\; (0.97176)^2 = T/273 \;\rightarrow\; T = 257.8K$. Converting to Celsius gives $T = 257.8 - 273 = -15.2$℃.

P11. (E) This solution references the points A-E as indicated on the diagram. Using Bernoulli's equation with points A and B, we get $P_A + \rho g H = P_B + \frac{1}{2}\rho v_B^2$. $P_A$ and $P_B$ both equal atmospheric pressure, so they cancel. Thus, $\rho g H = \frac{1}{2}\rho v_B^2 \;\rightarrow$ $v_B = \sqrt{2gH} = \sqrt{2(9.8)(1.50)} = 5.422$m/s.




Using the continuity equation with points B and C: $A_B v_B = A_C v_C \;\rightarrow\; \pi r_B^2 v_B = \pi r_C^2 v_C$.

This gives $(8.0cm)^2(5.422) = (7.0cm)^2 v_C \;\rightarrow\; v_C = 7.082$m/s. Using Bernoulli's equation with points B and C, we can find the air pressure in the siphon tube: $P_B + \frac{1}{2}\rho v_B^2 = P_C + \frac{1}{2}\rho v_C^2$. This gives $P_{atm} + (0.5)(840)(5.422)^2 = P_C + (0.5)(840)(7.082)^2 \;\rightarrow\; P_C = P_{atm} - 8718$. Because the air in the siphon tube connects points C and D, we know that $P_D = P_C = P_{atm} - 8718$. One last application of Bernoulli's equation, this time in the water with points D and E: $P_D + \rho g h = P_E \;\rightarrow$ $P_{atm} - 8718 + (1000)(9.8)h = P_{atm}$. This gives $9800h = 8718 \;\rightarrow\; h = 0.890m = 89.0cm$.

P12. (E) The voltage drop across the 45.0Ω resistor is $V_{45} = IR = (0.1043A)(45.0\Omega) = 4.694V$. We'll do some calculations assuming that nothing has actually failed. Looking at the left loop, we get $15.0 - 65I_{65} - 4.694 = 0 \rightarrow 10.3 = 65I_{65} \rightarrow I_{65} = 0.1586A$. Examining the right loop, we get $12.0 - 70I_{70} - 4.694 = 0 \rightarrow 7.31 = 70I_{70} \rightarrow I_{70} = 0.1043A$. We can see that this violates the node rule at the top node. We should have $I_{65} + I_{70} = I$. However, $I_{65} + I_{70} = 0.1586 + 0.1043 = 0.2629 \neq I = 0.1043$. That said, it is obvious that $I_{70} = 0.1043 = I$. This implies that the failure, whatever it is, has caused $I_{65} = 0$. The only choice that would cause that to be true is E, that the 65.0Ω resistor is open. Note: you can solve for I for each of the failure choices, and choice E is the only one that gives a value of 0.1043A for the current I.

P13. (D) For $Q_1$ we find $E_1$: $E_1 = \frac{kQ_1}{r_1^2} = \frac{(8.99\times10^9)(12.0\times10^{-9})}{(0.25)^2} = 1726$ N/C, directed entirely in the +y direction. So, $E_{1x} = 0$ and $E_{1y} = 1726$ N/C. For $Q_2$, we first need the distance from the charge to the point P: $r_2 = \sqrt{(0.25)^2 + (0.16)^2} = 0.2968$m. Now we can find $E_2$: $E_2 = \frac{kQ_2}{r_2^2} = \frac{(8.99\times10^9)(-18.0\times10^{-9})}{(0.2968)^2} = -1837$ N/C. The sign indicates the field points towards the charge; thus, $|E_2| = 1837$ N/C directed down and right. The angle at which it is directed is $\theta_2 = \tan^{-1}\left(-\frac{0.250}{0.160}\right) = -57.38°$. The electric field from the second charge must be broken into components: $E_{2x} = |E_2|\cos\theta_2 = (1837)\cos(-57.38) = 990.2$ N/C, and $E_{2y} = |E_2|\sin\theta_2 = (1837)\sin(-57.38) = -1547$ N/C. Adding the components to get the total electric field at the point P, we obtain: $E_x = E_{1x} + E_{2x} = 0 + 990.2 = 990.2$ N/, and $E_y = E_{1y} + E_{2y} = 1726 - 1547 = 178.7$ N/C. This gives a magnitude for the total electric field of $|E| = \sqrt{E_x^2 + E_y^2} = \sqrt{(990.2)^2 + (178.7)^2} = 1006$ N/C.

P14. (A) Although this arrangement is in an unstable equilibrium, it is in equilibrium, nonetheless. The torque is given by $\tau = IAB\sin\theta$, where $\theta$ is the angle between the magnetic field direction and the normal line from the loop area $A$. In the setup described and shown, the magnetic field is parallel to the normal line from the loop area (the normal line is perpendicular to the face of the loop). Thus, the angle is zero, $\theta = 0°$, and the torque on this loop is also zero: $\tau = IAB\sin(0°) = 0.00$ Nm.

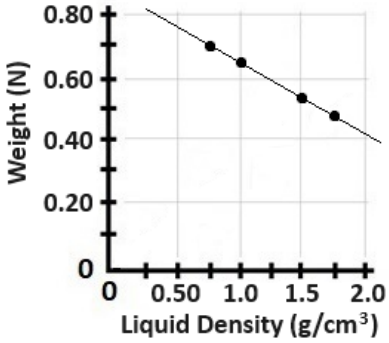
P15. (C) First, we find the electric field between the plates: $E = \frac{V}{d} = \frac{45.0}{0.020\times10^{-3}} = 2.25\times10^6$ N/C. Now we find the total electric field flux between the plates: $\Phi_E = EA = (2.25\times10^6)\pi r^2 = (2.25\times10^6)\pi(0.0125)^2 = 1104.5$ Nm$^2$/C. Turning to the Ampere-Maxwell equation and relying on the cylindrical symmetry of the problem, we find: $Bs = \mu_0\varepsilon_0\frac{d\Phi_E}{dt} \rightarrow B(2\pi r) = (4\pi\times10^{-7})(8.854\times10^{-12})\frac{(1104.5-0)}{4.20\times10^{-6}} \rightarrow$ $B(2\pi)(.0125) = 2.926\times10^{-9}$. This gives an induced magnetic field of $B = 3.725\times10^{-8}\,T = 37.3$ nT.

P16. (D) Since the star is very far away it has an object distance of $p_1 = \infty$. The focal length of the primary mirror is $f_1 = \frac{96}{2} = 48.0$cm. Thus, the primary image is located at $\frac{1}{p_1} + \frac{1}{q_1} = \frac{1}{f_1} \rightarrow$ $\frac{1}{\infty} + \frac{1}{q_1} = \frac{1}{48.0} \rightarrow q_1 = 48.0$cm. This image becomes the object for the secondary mirror: $p_2 = D_{ps} - q_1 = 40.0 - 48.0 = -8.0$cm. The focal length of the secondary mirror is $f_2 = \frac{-60}{2} = -30.0$cm. The secondary image is then found at $\frac{1}{p_2} + \frac{1}{q_2} = \frac{1}{f_2} \rightarrow \frac{1}{-8.0} + \frac{1}{q_2} = \frac{1}{-30.0} \rightarrow$ $q_2 = 10.91$cm. Now, this image becomes the object for the eyepiece lens: $p_3 = D_{sl} - q_2 = 45.0 - 10.91 = 34.09$cm. The final image is located at $\frac{1}{p_3} + \frac{1}{q_3} = \frac{1}{f_3} \rightarrow$ $\frac{1}{34.09} + \frac{1}{q_3} = \frac{1}{15.0} \rightarrow q_3 = 26.8$cm relative to the lens.

P17. (D) First, we normalize the wavefunction: $\int_{-\infty}^{\infty} \Psi^* \Psi dx = 1 \rightarrow$
$\int_0^1 A^2(1+2x)^2 dx = A^2 \int_0^1 (1+4x+4x^2)dx = 1.$
This gives: $A^2\left(x + 2x^2 + \frac{4}{3}x^3\right)|_0^1 = A^2\left(\frac{13}{3}\right) = 1 \rightarrow A = \sqrt{\frac{3}{13}}$ as the normalization constant. For the expectation value, we have: $\langle x \rangle = \int_{-\infty}^{\infty} \Psi^* x \Psi dx = \int_0^1 \frac{3}{13} x(1+2x)^2 dx$. This gives:
$\langle x \rangle = \frac{3}{13}\int_0^1 (x + 4x^2 + 4x^3)dx = \frac{3}{13}\left(\frac{1}{2}x^2 + \frac{4}{3}x^3 + x^4\right)|_0^1 = \frac{3}{13}\left(\frac{17}{6}\right)$. Thus, $\langle x \rangle = \frac{17}{26} = 0.654$.

P18. (C) The decay constant for the first isotope is $\lambda_1 = \frac{\ell n(2)}{15.4} = 0.0450\text{min}^{-1}$ and the decay constant for the second isotope is $\lambda_2 = \frac{\ell n(2)}{24.8} = 0.02795\text{min}^{-1}$. Thus, the combined activity after 60.0 minutes would be given by $A = (10.0\mu Ci)e^{-(0.0450 min^{-1})(60.0\text{min})} + (20.0\mu Ci)e^{-(0.02795 min^{-1})(60.0\text{min})}$.
This gives $A = (10.0)(0.0672) + (20.0)(0.1869) = 4.41\mu\text{Ci}$.

P19. (B) The weight for an individual point would be given by the difference between the gravitational force and the buoyant force. This can be written as $W = Mg - \rho Vg$. We cannot see the y-intercept, which would give the mass of the object, but we can use the slope of the best fit line to find the volume of the object. From the equation, we see $slope = -Vg$. To find the slope, I'll use two points on the best fit line. Specifically, I'll use (0.50, 0.75) and (1.25, 0.60). This gives:
$slope = \frac{0.60N - 0.75N}{1.25g/cm^3 - 0.50g/cm^3} = \frac{-0.15N}{0.75g/cm^3} = \frac{-0.15N}{750kg/m^3} = -0.0002\frac{m^4}{s^2}$.




So, $-Vg = -0.0002 \rightarrow V = 2.04 \times 10^{-5} m^3$. Now we use one of the data points to find the mass of the object. I'll use the point (0.75, 0.70). From our initial equation
$W = 0.70N = Mg - \left(\frac{0.75g}{cm^3}\right)Vg = M(9.8) - (750kg/m^3)(2.04 \times 10^{-5})(9.8)$. This gives
$0.70 = 9.8M - 0.15 \rightarrow M = 0.08673kg$. Finally, the density of the metal object is
$\rho_M = \frac{M}{V} = \frac{0.08673kg}{2.04 \times 10^{-5} m^3} = 4251kg/m^3 = 4.251g/cm^3 \approx 4\ g/cm^3$.

P20. (E) The relationship between the phase angle, the resistance, and the reactance is quite simple: $\tan\phi = \frac{X}{R}$. For the first data point, this gives: $\tan(61.9) = \frac{X}{80.0} \rightarrow X = (80.0)(1.873) = 150\ \Omega$. The other data also give the same result.