E-Bowl 2010: Preliminary Exam Answers and Solutions

1. C
2. C
3. C
4. B
5. D
6. C
7. C
8. D
9. E
10. D
11. C
12. D
13. C
14. A
15. A
16. B
17. A
18. A
19. B
20. C
21. C
22. C
23. D
24. B
25. A
26. C
27. A
28. D
29. B
30. C
31. A
32. A
33. A
34. A
35. B
36. A
37. A
38. A
39. A
40. D

1. C. Assume a composition with 100 grams. 75.69 g C/12.0 g = 6.3075 mol C;
8.80 g H/1.0 g = 8.80 mol H; 15.51 g O/16 g = 0.969375 mol O.
Guess there is one mole of oxygen: 1/0.963975 = 1.031592521
Multiply moles of C and H by 1.031592521 to yield: 6.507 mol C and 9.078 mol H and 1 mol O
To obtain integers, multiply by two to give: $C_{13}H_{18}O_2$

2. C. The force from m_2 is 4 times as great as the force from m_1. To balance, the test mass needs to be twice as far away from m_2 as it is from m_1. The only solution then is for the mass to be d/3 from m_1 and 2d/3 from m_2.

3. C. Note that the derivatives repeat; thus, f'= $f^{(5)}$. To find $f^{(2001)}$, we only need f' = sin(x) + cos(x)

4. B. Potential due to point charge or charged sphere: $V = Q_0/(4 * \pi*\varepsilon_0* r)$, r = 2R, V(2R) = $9*10^9 * 3*10^{-12}/(2*0.01)$ = 1.35 V.

5. D. Use PV=nRT, where R = 0.0821 L*atm/(mol*K), T=373 K, P = 1 atm. 64 g/mol

6. C. $f'(x) = 3x^2 + 8x + 5$. Critical values are -1 and -5/3. -1 yields a minimum and -5/3 yields a maximum. f(-1) = -1 + 4 – 5 + k = 5. k = 7

7. C. limit as 1/cos(x) = 1

8. D. Maximum and minimum are three standard deviations from the mean. Thus, 99.7%.

9. E. Take the second derivative of each position function to obtain an acceleration function. None of them are constant.

10. D. Impulse if F*dt. F is 0.2 kg * 9.8 m/s^2. To find the time, use the kinematic equations. The time to fall from 30 m to 0 m is 2.47 seconds, and the time from 0 m back to 15 m is 1.75 seconds ($d = vt + 1/2at^2$). Thus, the total time is 4.22 seconds. 0.2*9.8*4.22 = 8.3 N*s.

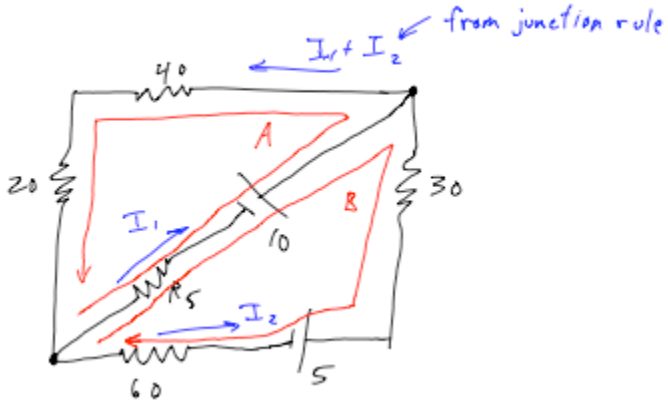
11. C. After a very long time, the inductor has no effect and acts as wire. Thus, I = V/R = 9/0.90 = 10.0 A.

12. D. [(1000 g vapor) / (18.016 g vapor/mol vapor)](40.7 kJ/mol vapor)(1 mol ice / 6.01 kJ)(18.016 g ice/mol ice) = 6772 g = 6.67 kg ice

13. C. First derivative is $1/(2\sqrt{x})$. At x=4, the derivative is 1/4.

14. A. $V = 4/3\ \pi r^3$, $dV = 4\ \pi r^2 dr$ = **3.6 π**

15. A.

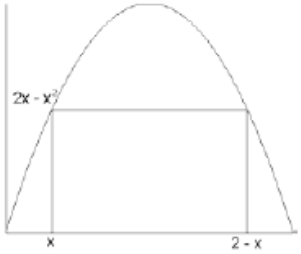


A: $-R_5I_1 + 10 - 40\,(I_1 + I_2) - 20\,(I_1 + I_2) = 0$
B: $-R_5I_1 + 10 + 30\,I_2 - 5 + 60\,I_2 = 0$
Simplified: A: $(60 + R_5)\,I_1 + 50\,I_2 = 10$; B: $R_5I_1 - 90I_2 = 5$
3A + 2B: $(5R_5 + 180)\,I_1 = 40$
$I_1 = 8/(R_5 + 36)$ = 1/12 from bottom left to top right

16. B. If you fail to reject H_0 when it is false, it is a Type II Error.

17. A. The equation is homogeneous.

18. A.



Area = $A(x) = (2 - 2x)(2x - x^2) = 2x^3 - 6x^2 + 4x$
$A'(x) = 6x^2 - 12x + 4 = 0 \qquad x = 1 \pm \sqrt{3}/3$
Since $1 - \sqrt{3}/3$ is between 0 and 1, then this is the value for x
$A(1 - \sqrt{3}/3) \approx 0.77$ **A**

19. B. $0.6^{10} = 0.0060$.

20. C. Charge density=$Q_0/L = 2.5*10^{-4}$ C/m
dq (the charge of a small piece of rod with length dx) = charge/length * length of piece = $\lambda\,dx$
$dE=dq/(4\pi*\varepsilon_0*r^2) = \lambda\,dx/(4*\pi*\varepsilon_0*(b+x)^2)$
E=integral of dE from 0 to L = $\lambda/(4\,\pi*\varepsilon_0) * (-1/(b+L) + 1/b) = 7.5\ 10^6$ N/C

21. C. In general, power is the rate of energy transfer. Here, it's the rate at which electrical energy converts into heat energy. So, the inventor wants to maximize the power. Since $P = i^2*R$, it follows that she wants to maximize the current through the resistor. In other words, she wants the peak current through the circuit, i_m, to be as large as possible.
In analogy with Ohms Law for DC circuits ($i=V/R$), the maximum current that flows through an AC circuit is $i_m = \varepsilon_m/Z$, where Z is the impedance ($\sqrt{(R^2 + (\omega L - 1/(\omega C))^2}$)

To make Z as small as possible for a given R, the stuff inside the parentheses (ωL-1/(ωC)), must equal zero. Therefore, ω =2*π*f = 2*π*60 Hz =377 s^{-1}. Then, L = 1/(ω^2*C) = 1/(377^2*0.2F) = 3.52 * 10^{-5} H.

22. C. This statement describes **Thévenin's theorem**.

23. D.

$$\frac{dy}{dx} = x + \frac{3x}{\sqrt{25-x^2}} \Rightarrow y = \frac{x^2}{2} - 3\sqrt{25-x^2} + C$$

Using the initial condition of (0, -10), $C = 5$.

Thus, the answer is $y = \frac{x^2}{2} - 3\sqrt{25-x^2} + 5$. **D**

24. B. A concentrated upward force F makes the V curve jump up by F.

25. A. APF=N_{atoms}*V_{atom}/$V_{unitcell}$; V_{atom} = 2R√(2); N = 4, V_{atom}=4/3*π*R^3; for FCC, a = 2R√(2); a^3 = 16R^3 √2; APF = 0.74.

26. C. Three independent state properties would be required.

27. A. F_{AB} = 30 kN (Compressive); F_{BC} = 70 kN (compressive)
ΔL_{AB} = FL/(AE) = 0.25 * (-30,000)/(π*0.03^2/4 *200*10^9) = -5.305*10^{-4} m = -0.05305 mm
ΔL_{BC} = 0.3 (-70,000)/(π*0.05^2/4 *105*10^9) = -1.01859 *10^{-4} m = -0.10185916 mm
ΔL_{ABC} = ΔL_{AB} + ΔL_{BC} = -0.1549 mm

28. D. F = degrees of freedom, C = number of components, P = number of phases;
F = C-P+2; F = 2-1+2 = 3.

29. B. 1-$e^{(-.25(Xa-Xb)^2)}$, where X_a and X_b are the values of electronegativity of the elements.

30. C. Net heat flow is the area of the triangle. A = 2T_0*4S_0/2 = 4T_0S_0

31. A. To find the strongest acid, another H^+ must be added. The only two available spots are the nitrogen and oxygen. Since nitrogen is the less electronegative of the two, $[CH_3NH_2OH]^+$ is the answer.

32. A. Markovnikov's Rule states this principle.

33. A. Inheritance states this principle.

34. A. Choice A complies with the standard for "competence."

35. B. Titles of graphs must be below the graphs.

36. A. "Recommend" is an action verb; "of" and "for" are prepositions.

37. A. Current dollars are the cash flow at the time of a transaction.

38. A. Christian Ramirez was a former Engineering Bowl director. Danielle Rickman was the executive director for E-Week 2009, and Matthew Sobieski was a former E-Fair director. David Hwang is the present E-Bowl director.

39. A. The first four departments were Mechanical, Chemical, Civil, and Electrical Engineering. Aerospace engineering was not.

40. D. When you enter Weil Hall from the west, you are on the third floor.