5 Star Science

Division C

Science Olympiad 2007

PA State Finals

April 27, 2007

1st Tiebreaker: One of the most famous experiments in physics was the Michelson–Morley experiment. What did the Michelson–Morley experiment disprove?

SCHOOL NAME_____ SCHOOL CODE_____

INSTRUCTIONS

1. **Turn in all exam materials at the end of this event. *Missing exam materials will result in immediate disqualification of the team in question*. There is an exam packet and a blank answer sheet.**

2. **You can divide up the test as you see fit. Each of you can work on the same or separate questions. You may separate the pages of the test. Re-staple them only when directed by the supervisor. Keep the answer sheets separate.**

3. **You may remove material from your reference binder during competition.**

4. ***Only the answers provided on the answer page will be considered.***

5. **UNITS and SIGNIFICANT FIGURES! Need I say more?**

6. **Include school name and school code in the appropriate locations on the answer sheet as well as on the title page. Indicate the names of the participants on the answer sheet.**

7. **Point values for each question are in parentheses. Tiebreaker questions are identified with a number indicating the first, second, third, etc. *Tiebreaker (except for the first on the title page) questions count toward the overall grade and are only used as tiebreakers in the event of a tie.***

8. **When the time is up, *the time is up*. Continuing to write after the time is up risks immediate disqualification.**

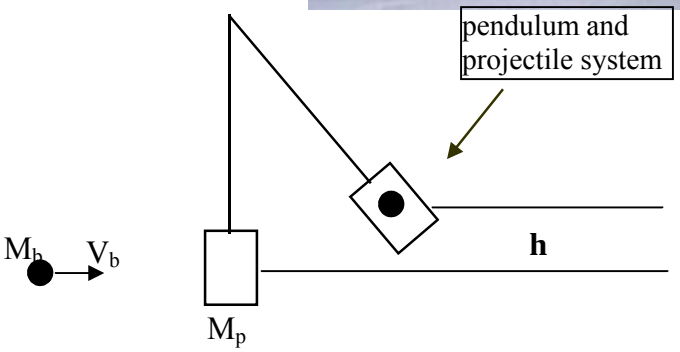
9. **NON-PROGRAMMABLE CALCULATORS ONLY. DON'T ASK, THE ANSWER IS NO.**

Physics

Section 1

Physics Lab Ballistic Pendulum (10 pts)

A ballistic pendulum is shown in the picture to right. A simplified sketch is shown below it. Ballistic pendulums are used to determine the speed of a projectile. The projectile (bullet or ball) is fired and collides inelasticly with a pendulum. A mechanism allows the pendulum and projectile to rotate to a higher height thus gaining gravitational potential energy.



M_b mass of bullet	66.2 g
M_p mass of pendulum ONLY	247.5 g
Height raised	7.05 cm

1. Determine the gravitational potential energy of the pendulum and projectile system.

2. Determine the kinetic energy just after the collision.

3. Determine the speed of the system just after the collision.

4. Determine the momentum of the system just after the collision.

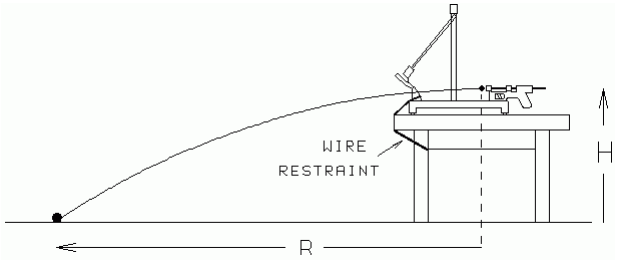
5. Determine the momentum bullet before impact.

6. Determine the speed of the bullet before impact.

7. The bullet was fired from a gun that used a spring. The spring was compressed 3.10 cm. Assuming no friction, what is the spring constant?

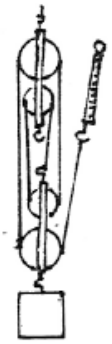
8. How much energy is stored in the compressed spring?

9. Another way of determining the speed of the projectile is to simply remove the pendulum and fire the projectile. If the height (H) of the device is 0.951 meters, determine the time it takes the projectile to hit the floor?



10. If the range (R) is 2.5 meters, determine the speed of the projectile?

Physics Questions (10 pts)



11. What is the ideal mechanical advantage of this pulley system?(1pt)

12. The mass of the block is 2.115 kg and it is raised 1.00 meters in 3.21 seconds. How much power is required? (1pt)

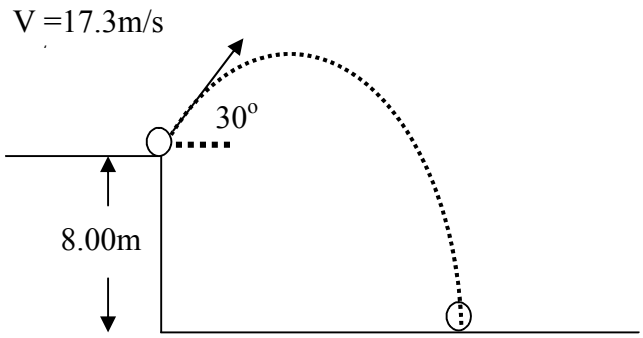
13. An object is moving with an initial velocity of 55 m/s. It accelerates at -2.4 m/s^2 for 31 seconds. What is the final velocity?

14. At the surface of the planet Idian, the acceleration due to gravity is 7.53 m/s^2. What is the acceleration due to gravity at 3 times the radius of the planet? (1pt)

15. Bob, whose mass is 50.0 kg, is ice skating with a constant speed of 6.51 m/s when he hits a rough patch of ice with a coefficient of friction 0.0812. How much time will it take Bob to come to a stop? (2 pts)

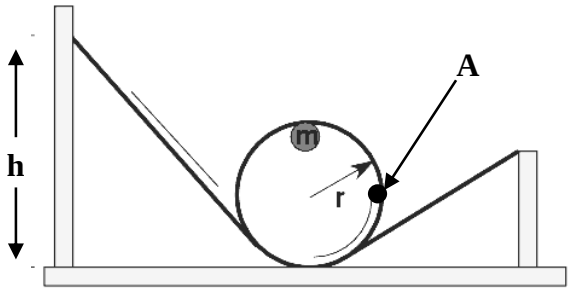
Physics Questions (cont.)

16. Determine the max height of the ball measured from the bottom of the cliff. ($g = 9.81\ m/s^2$) (1pt)



17. The displacement of a mass spring system is given $x(t) = 5\cos(3t)$. What is the acceleration of the system as a function of time? (1pt)

18. A ball of mass m is released at the top (height of 2.00 meters) of the track. What is the normal force exerted by the track on the mass m at point A? Assume no friction and do not take into account the rotational energy of the ball. (1pt)



h = 2.00 meters, r = 1.00 meters,
$g = 9.81\ m/s^2$, mass = 0.40 kg

19. How much work is done during one orbit by gravity on a 1000 kg satellite traveling in a circular orbit with a radius of 6×10^6 meters and a velocity of 8000 m/s. (1pt)

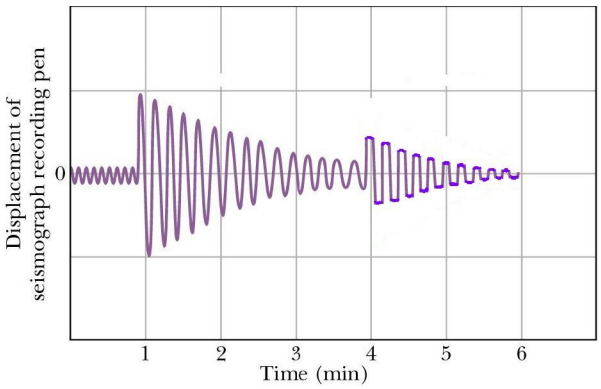
Earth and Space

Section 2

Earth and Space Lab – Earthquakes (10 pts)

In this virtual lab you will be determining the distance to the epicenter of an earthquake and answering other earthquake related questions.

To the right is a seismograph showing the arrival time of both a P and S wave created by an earthquake.



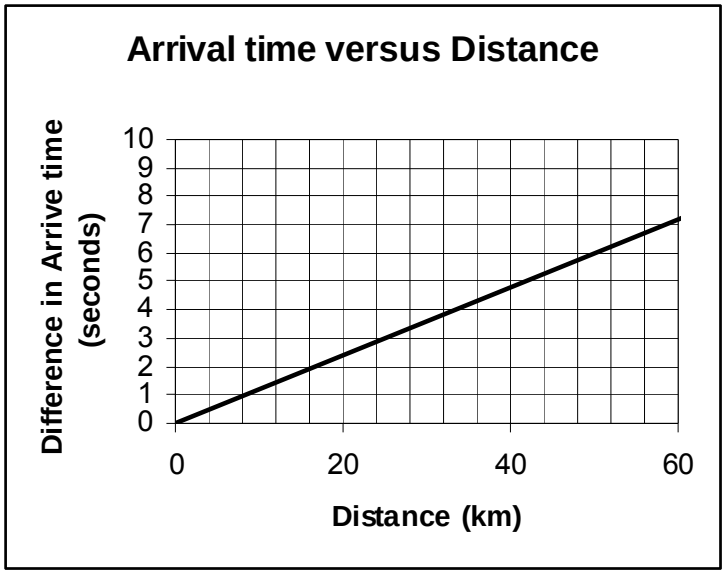
20. Which wave (P or S) always arrives first? (1pt)

21. What kind of wave is an S wave? (1pt)

22. What is the difference in arrival time of the P and S wave? (1pt)

23. How much bigger is the amplitude of a 7.0 earthquake compared to a 5.0 measured on the Richter scale? (1pt)

24. Assume that the difference in arrival time of the P and S wave is 5 seconds. Using the graph on the right, what is the distance from the recording station to the earthquake? (1pt)



The table below gives the distances to the epicenter from the recording stations located in

Seattle	725 miles
San Francisco	950 miles
Salt Lake City	375 miles

25. From the table, find the epicenter of the earthquake and locate it on the map on the answer sheet. You must use **all** three distances and **label them** on the map and **label** the epicenter. (5 pts)

Earth and Space Questions (10 pts)

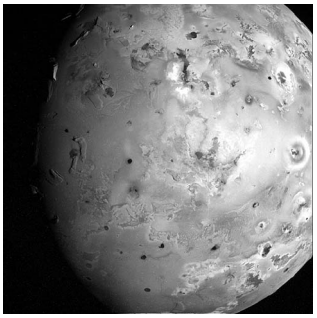
26. Spring tides occur when? (1 pt)

27. What is a caldera? (1 pt)

28. What kind of volcanic structure is this? (1 pt)

29. What is a subduction zone? (1 pt)

30. What makes Jupiter's moon Io the most volcanically actively body in the solar system? (1 pt)



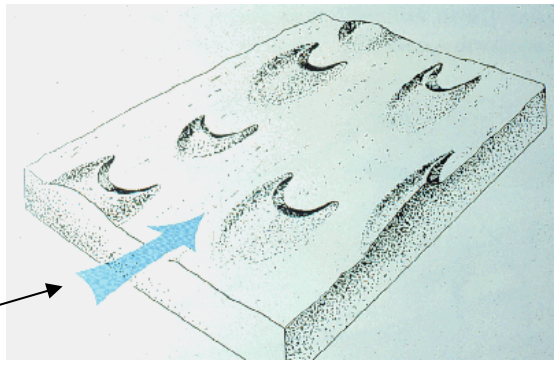
31. The primary difference between valley glaciers and continental ice sheets is that (1 pt)
    1. the ice sheets do not flow.
    2. the valley glaciers form at high altitudes while the ice sheets form at high latitudes.
    3. the valley glaciers form in warm periods as well as cold periods.
    4. the ice sheets initially develop at the poles and valley glaciers can develop in any mountain chain.
    5. ice sheets are larger than valley glaciers.

32. Why is the inside of the Earth still hot? (1 pt)

33. Which part of the atmosphere is closest to the earth's surface? (1 pt)

34. Hurricanes get their energy from warm ocean weather. But they do not form within 5 degrees of the equator? Why? (1 pt)

35. What kind of dune is shown in the picture? (1 pt)
    1. barchan dunes
    2. longitudinal dunes
    3. transverse dunes
    4. star dunes



Inquiry

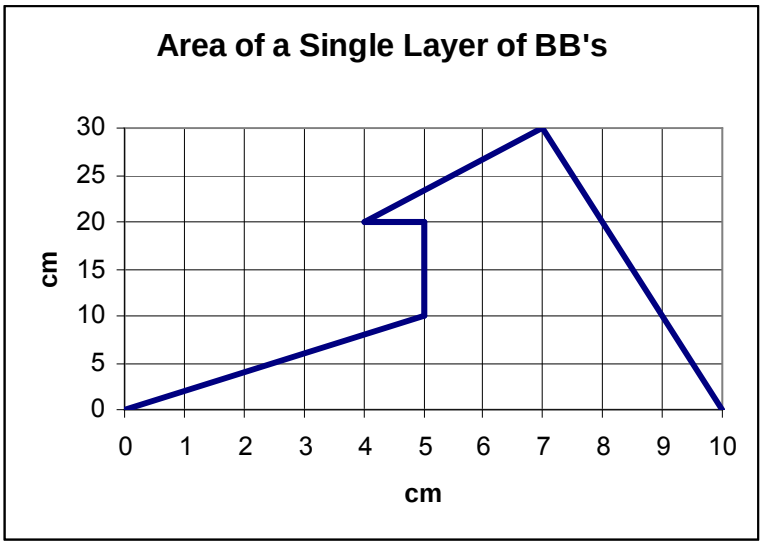
Section 3

Inquiry Lab (10 pts)

In this experiment, you will estimate the diameter of a BB (small sphere).

Background
Most material has a constant volume assuming that the individual particles are closely packed. For example the volume of pancake batter is the same whether it is in a mixing bowl or spread out on a counter top.

36. The BB's are spread out in a single layer. They are still tightly packed but the area is oddly shaped . What is the surface area as shown by the diagram on the right? (2 pts)



37. Let us assume the volume of BB's is measured to be 14.0 mL in a graduated cylinder and the actual surface area is 25.5 cm^2. Determine the diameter or height a single BB. (2 pts)

38. The calculated value of the diameter of a BB is always higher than the actual value. Why? (1pt)

39. Assume that you determine the diameter of a BB to be 0.0075 meters and the actual value is 0.0070 meters. Calculate the percent error. (1pt)

40. Assume that you determine the diameter of a BB to be 0.0080 meters. Through a completely separate method you determine the actual value of the diameter to be 0.0065 meters. Calculate the percent difference. (1pt)

41. Differences are usually normally distributed. Assume the diameter of a large group of marbles has a mean of 1.0 cm and a standard deviation of 0.10 cm. What percent of data will be within 2 standard deviations of the mean? (1 pt)

42. In classic science, what is a null hypothesis? (1 pt)

43. Please measure the below line as accurately as possible. (1 pt)

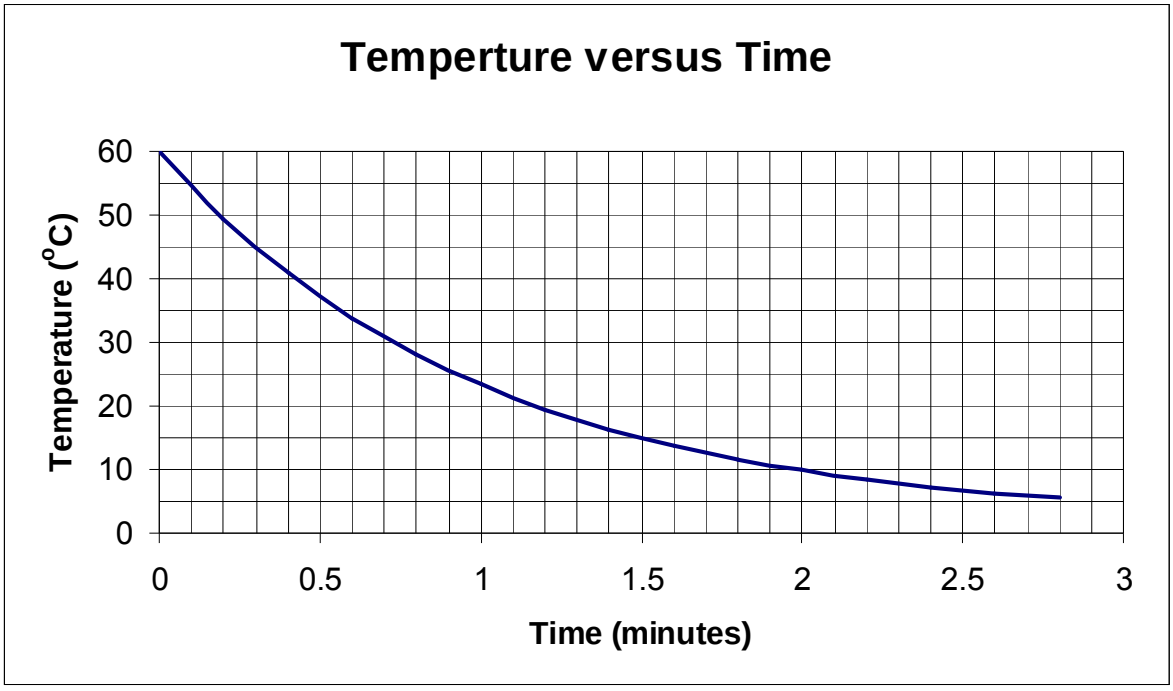
Inquiry Questions (10 pts)

44. Calculate the density of an object if its mass is 121.35 g and its volume is 31.2 mL. (1pt)

45. How many km are in 2.7 nautical miles? (1pt)
    1 nautical mile = 1.151 miles
    1 mile = 5280 feet
    1 inch =2.54 cm.

46. Using the below graph of temperature versus time, what is the average rate of change of temperature from t = 0.4 minutes and t = 2 minutes? (1pt)

47. Using the below graph of temperature versus time, what is the instantaneous rate of change of temperature at t = 0.9 seconds? (1pt)



48. Measure the unknown object with the micrometer. (1 pt)

49. On the answer sheet is a graph of sample data. Accurately draw the best fit STRAIGHT line AND write the equation of the relationship shown by the graph. (2 pts)

50. Here are the ages of relatives at a family reunion. Create a histogram on the answer sheet with 10 bins. Label the center of each bin. (3 pts)

Bullwinkle	59
Rocky	65
Bugs	25
Daffy	95
Wylie	63
Mickey	31
Minnie	12
Lucy	17
Linus	63
Asterix	6
Obelix	37
Donald	29
Sam	25
Taz	51

Biology

Section 4

Biology Lab (10 pts)

A well-watered green plan was exposed to sunlight for 3 days. It was then covered with a black cloth (no light) for several days. Leaves were removed and tested in 3 separate solutions. The three solutions are Fehling's, Bendedict's and Lugol's.

51. Benedict's solution tests for what substance? (1 pt)

52. Lugol's solution tests for what substance? (1 pt)

53. All tests were negative. Fehling's solution is a test for simple sugars, which is produced during photosynthesis. Why are no simple sugars detected? (2pts)

54. Give two examples of a monosaccharide. (2 pts)

55. What additional product is formed when two monsaccharides become a disaccharide? (1 pt)

56. If there is no light coming into the cholorplasts, how will affect the Calvin cycle? (1 pt)

57. Give the equation for cellular respiration. It does not have to be balanced. (1pt)

58. Choose the sequence in which electrons move downhill during aerobic respiration. (1pt)
    1. glucose --> ATP --> oxygen
    2. glucose --> ATP --> electron transport chain --> NADH
    3. food --> glycolysis --> Krebs cycle -->NADH --> ATP
    4. food --> Krebs cycle--> ATP --> NAD+
    5. food --> NADH --> electron transport chain --> oxygen

Biology Questions (10 pts)

For the multiple choice questions, only give the number that corresponds to the answer.

59. Two different plant families belonging to the same order must also belong to the same
    1. class
    2. species
    3. variety
    4. phylum
    5. genus

60. How is bone different from other tissues?
    1. It lacks cartilage.
    2. Its cells are in an extracellular secretion.
    3. It lacks a nerve supply.
    4. It is composed entirely of nonliving tissue.
    5. It lacks a blood supply.

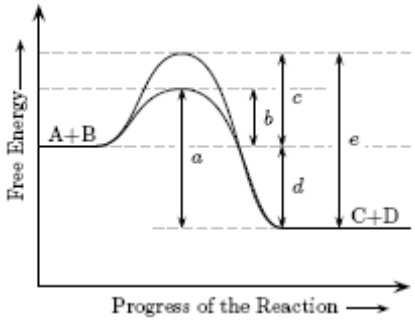
61. Which is a type of drug used in the treatment of AIDS?
    1. AZT
    2. reverse transcriptase inhibitor
    3. protease inhibitor
    4. All of these

62. Which of the following is not an important function of the liver?
    1. urea secretion
    2. glucose removal from the blood
    3. plasma protein production
    4. glycogen storage
    5. chemical poison detoxification in the blood

63. The excretory organs in the insects create an excretory fluid by secreting K+ ions, which draw water osmotically. These organs branch off anterior to the hindgut and are called
    1. flame cells.
    2. kidneys.
    3. Malpighian tubules.
    4. glomeruli.
    5. loops of Henle.

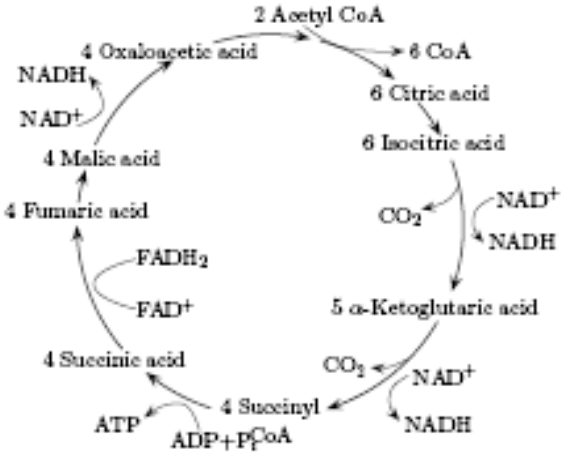
64. Vertebrates that practice internal fertilization employ three strategies for embryonic and fetal development. The strategy in which the female retains the young and the young develop and obtain nourishment from the female's blood is referred to as
    1. oviparity.
    2. ovoviviparity.
    3. viviparity.
    4. protogyny.
    5. protandry.

65. Consider the reaction A + B --> C + D shown on the right. Which of the following would remain the same with or without an enzyme?
    1. a
    2. b
    3. c
    4. d
    5. e

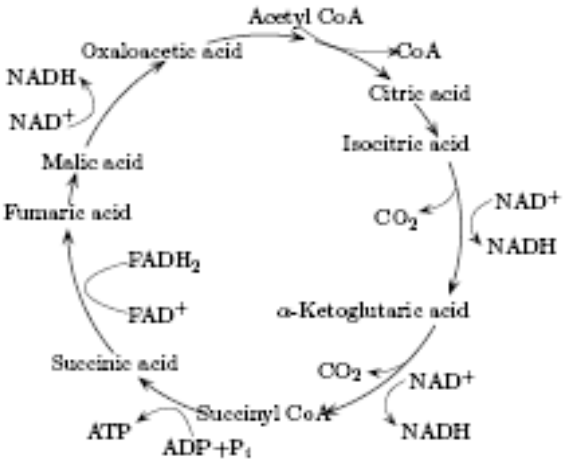


66. How did mitochondria originate assuming that the endosymbiotic theory of the origin of eukaryotic cells is based on solid evidence?
    1. from engulfed, originally free-living prokaryotes
    2. from the nuclear envelope folding outward and forming mitochondrial membranes
    3. by tertiary endosymbioses
    4. from infoldings of the plasma membrane, coupled with mutations of genes for oxygen- using metabolism
    5. a protoeukaryote became symbiotic with a protobiont

67. Carbon skeleton for amino acid biosynthesis are supplied by intermediates of the Krebs cycle. Which intermediate would supply the carbon skeleton for synthesis of a 5-carbon amino acid?
    1. citric acid
    2. isocitric acid
    3. malic acid
    4. α-ketoglutaric acid
    5. succinic acid



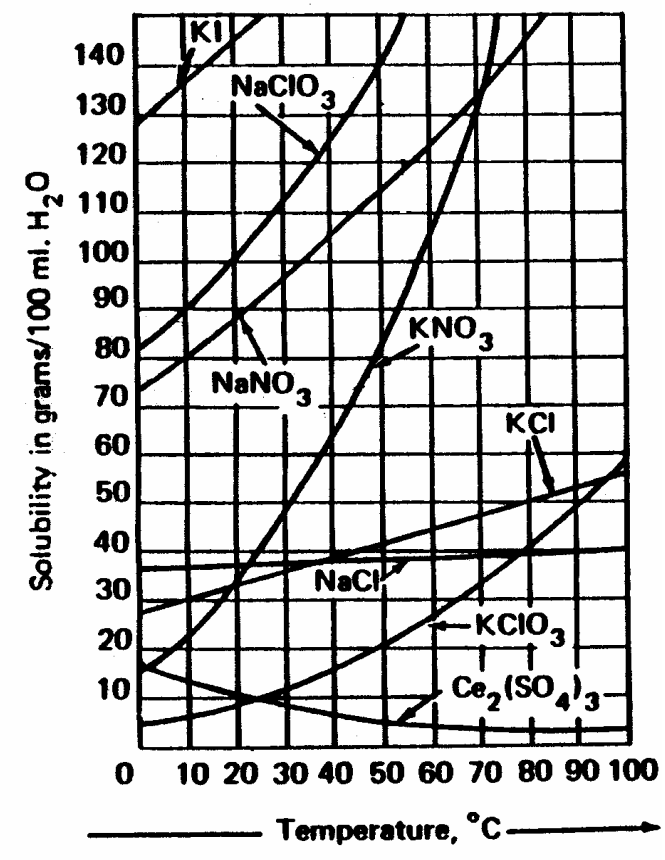
68. How many ATP molecules can be made through substrate-level phosphorylation and oxidative phosphorylation if you started with succinyl CoA and ended with oxaloacetate?
    1. 7
    2. 5
    3. 15
    4. 6
    5. 9



Chemistry

Section 5

Chemistry Lab: Solubility Curves (10 pts)



69. Which of the salts shown on the graph is the least soluble in water at 10°C? (1 pt)

70. At what temperature do saturated solutions of potassium nitrate and sodium nitrate contain the same weight of solute per 100 ml of water? (1 pt)

71. How many grams of potassium chlorate must be added to 2 liter of water to produce a saturated solution at 50°C? (1 pt)

72. Twenty grams of KCl are dissolved in 100 mL of water at 45°C. How many additional grams of KCl are needed to make the solution saturated at 80°C? (1 pt)

73. What is the smallest volume of water in ml required to dissolve completely 40 grams of $NaC1O_3$ at 19°C? (1pt)

Are the following solutions saturated, unsaturated or supersaturated? (Assume that all three could form supersaturated solutions.

74. 40 g of KCl in 100 ml of H_2O at 80°C. (1pt)
75. 120 g of KNO_3 in 100 ml of H_2O at 60°C. (1pt)
76. 80 g of $NaNO_3$ in 100 ml of H_2Oat 10°C. (1pt)

77. Draw and **label** a line on the graph **<u>on the answer sheet</u>** that represents the general trend for the solubility curve for a gas such as ammonia at one atmosphere. (1 pt)

78. Calculate, to one significant figure, the molality of a saturated solution of sodium chlorate at 24 degrees C. Assume the density of water to be 1.0 g/ mL. (1 pt)

Chemistry Questions (10 pts)

79. What is the IUPAC name of $Sn(Cr_2O_7)_2$? (1 pt)

80. Determine the order from smallest to largest atomic radius of the elements B, F, Ge, Pb? (1 pt)

81. Complete and balance the following combustion reaction. (1 pt)

$$\_\_\_\_CH_3CH_2CH_2CH_3 + \_\_\_\_O_2 \Rightarrow \_\_\_\_\_CO_2 + \_\_\_\_H_2O$$

Consider the following balanced chemical equation.

$$CH_4\,(g) + 2\,O_2\,(g) \text{ -----> } CO_2 + 2\,H_2O$$

The gram formula weights are

CH_4 (g) = 16.0 g O_2 (g) = 32.0 g CO_2 = 44.0 g H_2O = 18.0 g

82. If 10.0 grams of CH_4 react with 50.0 grams of O_2, how many grams of H_2O are produced? (1pt)

83. Using information in the previous question, determine which reactant is the limiting reagent and how many grams of the excess reactant are left? (2 pts)

84. How much energy is needed to melt 5 grams of -7°C ice and heat it to 35°C? (1 pt)

$L_{f\ (ice)} = 80 \frac{\text{calories}}{\text{gram}}$ $C_{ice} = 0.5 \frac{\text{calorie}}{\text{gram} \bullet ^\circ\text{C}}$ $C_{water} = 1.0 \frac{\text{calorie}}{\text{gram} \bullet ^\circ\text{C}}$

Consider the following system at equilibrium. The reaction is exothermic in the formation of the products as written. Predict the direction the equilibrium will shift (left or right) or the effect on the concentration (increase, decrease, or no effect) of the molecule in question for each of the stresses described below.

$$2\ NH_3\ (g) \quad \leftrightarrow \quad N_2\ (g) \quad + \quad 3H_2\ (g)$$

85. Change: increase in $[N_2]$
What is the direction of the shift?

86. Change: increase in temperature
What is the effect on the concentration of $[N_2]$?

87. Change: increase in pressure
What is the effect on the concentration of NH_3?