Chemistry Lab

Syosset High School

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Name:

Date:

Directions: Answer each question to the best of your ability. You will have fifty minutes to complete the entire examination, budget your time wisely and if you find a question to be difficult, move on as quickly as possible. Also SHOW ALL OF YOUR WORK, OR YOU WILL RECEIVE NO CREDIT

Part 1: Write the formula for each ionic compound under each compound name (2 points each, partial credit will be awarded based on how correct each answer is):

1)Sodium Carbonate 2) Potassium Nitrate 3) Beryllium Fluoride

4)Iron (II) Oxide (Also known as ferrous oxide) 5) Calcium Carbonate

Part 2: Write the name of the compound for each given formula (2 points each, partial credit will be awarded based on how correct each answer is):

6)$Cu(NO_3)_2$ 7)KCl 8)LiClO

9)$FeBr_2$ 10)NiO

Part 3: Balance each equation (1 points each, no partial credit). Write the full balanced equation next to the given reaction

11) NO2+H2O –> HNO3+NO:

12) PCl3 + H2O –> H3PO3 + HCl:

13) P2H4 –> PH3 + P4:

14) P4 + Cl2 –> PCl3:

15) FeCl3 + H2S –> Fe2S3 + HCl:

16) Mg3N2 + H2O –> Mg(OH)2 + NH3

17) PbO + NH3 –> Pb + N2 + H2O:

18) FeSO4 –> Fe2O3 + SO2 + O2:

19) S2Cl2 + NH3 –> N4S4 + NH4Cl + S8:

20) C3H7CHOHCH(C2H5)CH2OH + O2 –> CO2 + H2O:

Part 4: (5 points per question):

21. The mineral spodumene has the empirical formula LiAlSi2O6. Given that the percentage of lithium-6 atoms in naturally occurring lithium is 7.40%, how many lithium-6 atoms are present in a 518-g sample of spodumene?

22. A hydrocarbon mixture consists of 60.0% by mass of C_3H_8 and 40.0% of C_xH_y. When 10.0 g of this mixture is burned, 29.0 g CO2 and 18.8 g H2O are the only products. What is the empirical formula of the unknown hydrocarbon?

23. A 1.013 g sample of ZnSO4 • x H2O is dissolved in water and the sulfate ion precipitated as BaSo4. The mass of pure, dry BaSO4 obtained is 0.8223 g. What is the formula of the zinc sulfate hydrate?

Part 5: 15 point question:

24. Some substances that are only very slightly soluble in water will spread over the surface of water to produce a film that is called a monolayer because it is only one molecule thick. A practical use of this phenomenon is to cover ponds to reduce the loss of water by evaporation. Stearic acid forms a monolayer on water. The molecules are arranged upright and in contact with one another, rather like pencils tightly packed and standing upright in a coffee mug. The model at the right represents an individual stearic acid molecule in the monolayer.

a) How many square meters of water surface would be covered by a monolayer made from 10.0 g of stearic acid if the formula is $C_{18}H_{36}O_2$? [Hint: Each stearic molecule is 0.22 nm^2 wide]

b) If stearic acid has a density of 0.85 g/cm^3, estimate the length (in nanometers) of a stearic acid molecule.

c) A very dilute solution of oleic acid in liquid pentane is prepared in the following way:

1.00 mL oleic acid + 9.00 mL pentane –> solution 1
1.00 mL solution 1 + 9.00 mL pentane –> solution 2
1.00 mL solution 2 + 9.00 mL pentane –> solution 3
1.00 mL solution 3 + 9.00 mL pentane –> solution 4

A 0.10 mL sample of solution 4 is spread in a monolayer on water. The area covered by the monolayer is 85 cm2. Assume that oleic acid molecules are arranged in the same way as described for stearic acid, and that the cross-sectional area of the molecule is 4.6 x 10^{-15} cm2. The density of oleic acid 0.895 g/mL. Use these data to obtain an approximate value of Avogadro's number (Oleic acid formula: $C_{18}H_{34}O_2$)

Part 6: These questions will ask about conceptual aspects of the gas laws along with possible calculations for certain values. Each question overall will be worth 5 points, further subdivisions will be noted within the questions.

25.
a) A massive, yet elastic container of neon gas holds 300 L at 50 atm. The container is then submerged in mercury, increasing pressure to 1000 atm. What is the final volume and what is the constant of proportionality if any (2 points)?

b) Assuming we approach Boyle's Law from a volume-centric point of view, does a "constant product of proportionality" mean pressure decreases the same interval as the volume increases the same interval? Explain mathematically (3 points).

26. Can there be a constant of proportionality in Charles Law? If so, what does the constant of proportionality relate? If not, what remains constant in Charles Law (5 points)? Finally, explain how the nature of proportionality either explains or is reflected by manipulation of the variables involved in Charles Law. Explain clearly.

27. Let statement A be 1 mole of gas and let statement B be 22.4 L of gas. Prove that 1 mole of gas equals 22.4 L of gas at STP going from A –> B (5 points).

28. Let your initial statements be the proportionalities from Boyle's Law, Charle's Law and Avogadro's Law. Prove the ideal gas law from A –> B (5 points).

Part 7:

29. Name 5 central tenets to the Kinetic-Molecular Theory of Gases (4 parts for every correct element):

1.

2.

3.

4.

5.

30. Derive Graham's Law starting from $P = (\frac{1}{3})(N/V)(m*u2)$, where N is the number of molecules, V is the volume, m is the mass of each molecule and u2 is the average squared speed. Define what variables you are using if you make any new variables (10 points)

31. Complete combustion of 1.110 g of a gaseous hydrocarbon yields 3.613 g CO_2 and 1.109 g H_2O. A 0.288g sample of the hydrocarbon occupies a volume of 131 mL at 24.8°C and 753 mmHg. What is the empirical formula of the hydrocarbon? (20)

32. A balloon is inflated with 2.15 ft^3 of He(g) at STP and released. What is the gas pressure in the balloon when it has expanded to a volume of 155L? Assume a temperature of -20°C at this altitude. (20) [Hint: 1 ft^3 = 28.3168 L]

33. A gaseous mixture of He and O_2 has a density of 0.518 g/L at 25°C and 721 mmHg. What is the mass percent He in the mixture? (10)

Part 8: 20 point question:

34. In research that required the careful measurement of gas densities, John Rayleigh, a physicist, found that the density of O2 (g) had the same value whether the gas was obtained from air or derived from one of its compounds. The situation with N2(g) was different. The density of nitrogen had the same value when it was derived of any various compounds, but a different value if it was extracted from air.

a) Why would the air extracted from the liquid air not have the same density as nitrogen obtained from its compounds?

b) Which gas had the greater density? The one extracted from the air or from the compounds? Explain.

c) The way in which Ramsay proved nitrogen extracted from the air itself was a mixture of gases involved allowing the nitrogen to react with magnesium. Explain the experiment's significance.

Part 9: 10 points each

35. A particular natural gas consists, in mole percents, of 83.0% CH_4, 11.2% C_2H_6 and 5.8% C_3H_8. A 385 L sample of this gas, measured at 22.6°C and 739 mmHg, is burned at constant pressure in an excess of oxygen gas. How much heat in kilojoules is evolved in the combustion reaction?

36. Use Hess' Law and the following data:

$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$ $\quad \Delta H^0 = -802$ kJ

$CH_4(g) + CO_2(g) \rightarrow 2\,CO(g) + 2\,H_2(g)$ $\quad \Delta H^0 = 247$ kJ

$CH_4(g) + H_2O(g) \rightarrow CO(g) + 3H_2(g)$ $\quad \Delta H^0 = 206$ kJ

To determine ΔH^0 for the following reaction $CH_4(g) + (½)O_2(g) \rightarrow CO(g) + 2H_2(g)$, an important source of hydrogen gas.

37. The metabolism of glucose, $C_6H_{12}O_6$, yields CO_2 (g) and H_2O (l) as products. Heat released in the process is converted to useful work with about 7-% efficiency. Calculate the mass of glucose metabolized by a 58.0 kg person in climbing a mountain with an elevation gain of 1450 m. Assume that the work performed in the climb is about four times that required to simply lift 58.0 kg by 1450 m. (Heat of formation of glucose is -1273.3 kJ/mol).

Part 10: 70 point question:

Given a reaction A + B <–> C, derive a relationship between the Gibbs free energy, the gas constant, temperature and the reaction quotient under nonstandard conditions, given that:

qrev = -w = R*T*ln(Vf/Vi)