Preparing for the Chemistry Portion of Science

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UIL Chemistry Exams

- 20 MC questions taken from 13 topic areas
- At least one question from each topic area on each exam
- Distractors catch common mistakes
- Some real world, situational problems
- Some problems with pictures or graphs
- Has to fit three page, two-column test format

13 topic areas

1. Fundamentals
2. Stoichiometry
3. Atomic Theory
4. Chemical Bonding and Structure
5. Gases
6. Liquids and Solids
7. Thermodynamics
8. Physical Equilibria
9. Chemical Equilibria
10. Acids and Bases
11. Solubility Equilibria
12. Electrochemistry
13. Chemical Kinetics

See the Director's Notes for a full description of each topic area.

Three-page, two-column test format

Plus a removable one-page data sheet.

C01. How many atoms are in one mole of C_6H_{14}?

A) 6.022×10^{23}
B) 1.204×10^{24}
C) 6.022×10^{24}
D) 1.204×10^{25}
E) 6.022×10^{25}

C02. What is the molar mass of gaseous dinitrogen tetroxide?

A) 30.01 g/mol
B) 44.02 g/mol
C) 46.01 g/mol
D) 88.04 g/mol
E) 92.02 g/mol

C03. What is the sum of the coefficients when this chemical equation is balanced?

$$Fe + \; H_2SO_4 \rightarrow \; Fe_2(SO_4)_3 + \; H_2$$

A) 12
B) 9
C) 8
D) 7
E) 4

C04. What is the pH of a 0.0075 M $Ba(OH)_2$ solution?

A) 12.18
B) 11.88
C) 7.5
D) 2.12
E) 1.82

C05. What is the mass percent iron in Fe_2O_3?

A) 30.06%
B) 34.97%
C) 55.85%
D) 69.94%
E) 111.70%

C07. How do the intermolecular forces in solid wax compare to the intermolecular forces in molten wax?

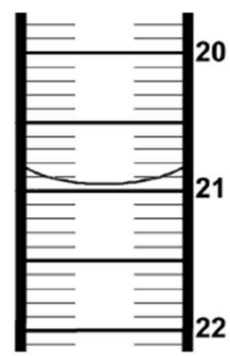
A) Solid wax has hydrogen bonding but molten wax only has dipole-dipole forces.
B) Solid wax has hydrogen bonding but molten wax only has dispersion forces.
C) Solid wax has dipole-dipole attractions, but molten wax only has dispersion forces.
D) Solid wax has dispersion forces and molten wax has no intermolecular forces.
E) The intermolecular forces in solid wax and in molten wax are the same.

C08. What is the net ionic equation for the reaction of lead(II) nitrate with potassium iodide?

A) $2\ PbNO_3(aq) + KI(aq) \rightarrow 2\ PbI(s) + KNO_3(aq)$
B) $Pb_2NO_3(aq) + KI(aq) \rightarrow Pb_2I(s) + KNO_3(aq)$
C) $Pb^{2+}(aq) + 2\ NO_3^-(aq) + 2\ K^+(aq) + 2\ I^-(aq) \rightarrow PbI_2(s) + 2\ KNO_3(aq)$
D) $Pb^{2+}(aq) + 2\ I^-(aq) \rightarrow PbI_2(s)$
E) $K^+(aq) + NO_3^-(aq) \rightarrow KNO_3(s)$

C09. What is the correct volume reading for the liquid in this burette?

A) 20.84 mL
B) 20.96 mL
C) 20.90 mL
D) 21.05 mL
E) 21.16 mL



C10. A piece of silvery metal measuring 2.0 cm × 2.0 cm × 5.0 cm has a mass of 178.60 g. Which of these metals is it most likely to be?

The removable data sheet for Chemistry contains

1) a periodic table,
2) water data and commonly used constants,
3) information that is specific to this exam.

Sometimes information is embedded in the problems, but I don't always have enough space in the test itself to do that.

Chemistry

1A 1	2A 2	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8	8B 9	8B 10	1B 11	2B 12	3A 13	4A 14	5A 15	6A 16	7A 17	8A 18
1 H 1.01																	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											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 = 40.7 kJ/mol
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

Thermodynamic Data

Compound	ΔH_f^o (kJ/mol)
$MgCl_2(aq)$	−801.2
$H_2O(\ell)$	−285.8
$HCl(aq)$	−167.2
$MgO(s)$	−601.6
$N_2O_4(g)$	+9.16
$NO_2(g)$	+33.18

Compound	ΔS^o (J/mol·K)
$N_2O_4(g)$	+304
$NO_2(g)$	+240

Physical Data for Ethanol

T_{mp} = −114.14°C
T_{bp} = 78.24°C
ΔH_{fus} = 106.3 J/g
ΔH_{vap} = 836.8 J/g
$c_{liquid\ ethanol}$ = 2.420 J/g·°C
$c_{solid\ ethanol}$ = 2.439 J/g·°C
$c_{gaseous\ ethanol}$ = 1.699 J/g·°C

Invitational A through State

- "The same test," only harder
- Scalable problems
- Increasingly quantitative
- Quantitative problems have more steps

Scalable Problems

- Inv A: How much heat is required to turn 225 g of ice at -10 °C into liquid water at 20 °C?
- Inv B: How much ice at -5.0 °C must be added to 100 g of water at 25 °C to bring the final temperature to 3.5 °C?
- District: If 225 g of ice at -20 °C is added to 315 g of water at 80 °C what will the final temperature of the water be?

Ways to make problems harder

- Give the chemical name instead of the formula.
- Don't balance the equation.
- Add more steps to a multi-step problem
- Ask about a quantity that doesn't appear explicitly in the equation. For example, PV=nRT includes density, molecular weight, and the mass of the sample.

Increasingly quantitative

- Sometimes harder because of the math, sometimes because you need to know a formula, sometimes just because it takes longer
- I don't like to ask "you know it or you don't" questions. No trivia questions.
- If I ask a definition on an early exam, expect that you'll need to know that word or concept on a later test
- Conceptual questions are not necessarily easier

Real world situational problems

A student tries to make 1000 mL of 0.500 M $ZnCl_2$ by combining 100 mL of a 5.00 M stock solution with 1000 mL of water. He quickly realizes his mistake, and decides to add more stock solution to the new solution to bring the final concentration to 0.500 M. How much additional stock solution should he add?

A chemist performs a crude titration by dropping NaOH pellets into a 50.0 mL solution of 2.24 M HNO_3 and counting how many pellets it takes to reach the phenolphthalein endpoint. If his NaOH is 96.7% pure and each NaOH pellet weighs 0.1602 grams, how many pellets will he have to add to make the solution turn pink?

Don’t expect to know all the answers

- The test content goes beyond AP Chemistry
- Some of this I have to look up myself just to be certain
- Step-by-step solutions are provided to coaches at each meet

Solutions for each exam

C10. (B) First calculate how many moles of H^+ are in the acid solution, and how many moles of NaOH are in each pellet:

$$\text{moles of H}^+ = 2.24\ \text{M} \times 0.050\ \text{L} = 0.112\ \text{mol H}^+$$

$$0.1602\ \text{grams/pellet} \times 0.967 \times \frac{1\ \text{mole NaOH}}{40.00\ \text{g}} = 0.003873\ \text{mol NaOH/pellet}$$

Divide the moles of H^+ by the moles per pellet of NaOH to determine how many pellets are required to neutralize the acid:

$$\frac{0.112\ \text{mol H}^+}{0.003873\ \text{mol OH}^-/\text{pellet}} = 28.92\ \text{pellets}$$

So the 29th pellet will result in an excess of NaOH and the solution will turn pink.

C11. (C) Assume a 1000 g sample. In that case the mass of NaCl in the sample is 36.0 g, and the sample volume is (1000 g)/(1.027 g/ml) = 973.7 mL = 0.9737 L.
(36.0 g NaCl)/(58.44 g/mol) = 0.616 mol NaCl
(0.616 mol)/(0.9737 L) = 0.633 M

C12. (A) The two-point Arrhenius equation relates the activation energy and rate constants at two different temperatures:

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

How to Prepare

- The best book or web site is the one that makes the most sense to the student.
- It doesn't have to be up to date.
- Understand the concepts, don't just memorize rules
- Memorize the formulas and know when and how to use them (in the correct units!)

Be sure to know these

- Naming compounds from formulas and writing formulas from names
- Calculating moles
- Stoichiometry!
- Using equalities as unit conversions

1. For the reaction

$$3NO_2 + H_2O \longrightarrow 2HNO_3 + NO$$

Hint: 46 g/mol 18 g/mol 63 g/mol 30 g/mol

What is the maximum amount of HNO_3 that could be formed from 184 g of NO_2 and 27 g of H_2O?

a) 126. g

b) 211. g

c) 94.5 g

d) 25.3 g

e) 168. g

Limiting Reactant Problem:

Find the limiting reactant first, then get the answer.

184/46 = 4 mol NO_2 which needs 4/3 = 1.33 mol H_2O

27/18 = 1.5 mol H_2O which is too much (excess)

base answer on the limiting amount – the NO_2

4 x (2/3) = 8/3 mol of HNO_3 produced

8/3 (63) = <u>168 g HNO_3</u>

2. Which of the following liquids has the highest vapor pressure?

a) H_2O

b) C_5H_{12}

c) C_2H_5OH

d) $C_{10}H_{12}$

- The liquid with the fewest/weakest intermolecular forces (imfs) will have the highest vapor pressure.
- Small imfs mean faster/easier vaporization rates and higher vapor pressures.
- Water and ethanol both have relatively strong imfs (H-bonding) and therefore have relatively low vapor pressures.
- Pentane and decane both only have dispersion forces which are very weak.
- Overall imf strength scales with molecular size – so decane has stronger imfs than pentane.
- So pentane will have the highest vapor pressure.

3. The heat of combustion ($\Delta H°$) for propane is 2220 kJ/mol. How many kJ of energy are released when 5.00 L of propane at 2.45 atm and 25°C is burned?

a) 1110 kJ

b) 2220 kJ

c) 1875 kJ

d) 555 kJ

e) 3330 kJ

V=5.00L; P=2.45atm; T (in K)=°C + 273.15

=298.15K

use the ideal gas law to get moles of propane

$n = PV/RT = (2.45 \times 5.00)/(0.08206 \times 298.15) = 0.500$ mol

$0.500 \text{ mol} \times 2220 \text{ kJ/mol} = 1110 \text{ kJ}$

Questions?