Appendix 1 Creative Exercises and matched questions for control groups

Setting 1

Group activity 1:

Based on everything you learned from Chapter 1 to 3, write down as many correct, distinct and relevant facts you can about:

120.1 g butane reacts with 278.5 g oxygen to form 203 g carbon dioxide and 195.6 g water. The reaction emits 1.19×10^5 J energy. (Density of oxygen is 1.429 g/L)

You'll receive 1 point for each statement. Seven statements will get you full credit for the problem.

Exam 1:

Based on everything you learned from Chapter 1 to 4, write down as many correct, distinct and relevant facts you can about:

251 kg Te-120 at the temperature of –22 °C (density of Te is 6.24 g/ cm^3)

You'll receive 3 points for each statement. Six statements will get you full credit for the problem.

Matched questions for control group:

1. For Te-120, which one of the following is TRUE?
   A. The atomic number is 120 B. The mass number is 52
   C. It contains 66 neutrons D. It contains 52 electrons E. It is a nonmetal
2. What volume in milliliters of table salt would be needed to measure out 145 kg of salt (density = 2.16 g/cm^5)
   A. 6.71×10^{-2} mL B. 67.1 mL C. 6.71×10^4 mL D. 3.13×10^2 mL E. 3.13×10^5 mL
3. A race metal alloy is a superconductor at -22 °C. What is the temperature on the Kelvin scale?
   A. – 251K B. 251 K C. 251.1 K D. 25.15 K E. 295.15 K

Group activity 2:

Based on everything you learned from Chapter 1 to 6, write down as many correct, distinct and relevant facts you can about:

61.6 kg $Al_2(SO_4)_3$

You'll receive 1 point for each statement. Seven statements will get you full credit for the problem.

Exam 2:

Based on everything you learned from Chapter 1 to 7, write down as many correct, distinct and relevant facts you can about:

107.87g $AgNO_3$ (aq) reacts with 36.46 g HCl (aq)

You'll receive 3 points for each statement. Six statements will get you full credit for the problem.

Matched questions for control group:

1. All of the following compounds are soluble in water EXCEPT:
   A. NaOH B. $CaBr_2$ C. FeI_3 D. NH_4NO_3 E. AgCl
2. What are the moles of 107.87 grams of silver nitrate?

A. 0.63498 B. 0.63 C. 169.88 D. 1.8×10^4 E. 6.4959×10^{25}

3. What type of a reaction occurs when a silver nitrate solution is mixed with a hydrochloric acid?
   A. combination B. decomposition C. single-displacement
   D. double-displacement E. no reaction occurs

Extra Credit:
Based on everything you learned from this course, write down as many correct, distinct and relevant facts you can about:
When 0.06 mol of Al reacts with 0.06 mole of Cl_2, the chemical reaction below occurs: 2 Al(s) + 2 Cl_2 (g) → 2 $AlCl_3$(aq), 4.0 grams of $AlCl_3$ is formed by the reaction and used to make 255 mL $AlCl_3$ solution.
You will receive 0.5 points for each statement. Ten statements will get you full credit (5 points) for this assignment.

Matched questions for control group:
1. Which one is the electron configuration of Al?
   A. $1s^2 2s^2 2p^6 3s^2 3p^1$ B. $1s^2 2s^2 2p^{10} 3s^2 3p^1$ C. $1s^2 2s^2 2p^6 3s^2$ D. $[Ne]3p^1$ E. $[Ar]4s^2 3p^1$
2. How many electrons in p subshell of Al?
   A. 0 B. 2 C. 6 D. 10 E. 13
3. How many electrons does Al^{3+} have?
   A. 0 B. 3 C. 10 D. 13 E. 16
4. When 0.06 mol of Al reacts with 0.06 mole of Cl_2, the chemical reaction below occurs: 2 Al (s) + 3 Cl_2 (g)→2 $AlCl_3$ (aq), how many grams of $AlCl_3$ can be made?
   A. 0.04 B. 0.06 C. 5 D. 8 E. 3
5. What is the morality when 4.0 grams of $AlCl_3$ is added to water to make 255 mL solution?
   A. 1.2×10^{-4} M B. 2.1×10^3 M C. 0.12 M D. 2.1 M E. 7.7 M

Setting 2

Group activity 1:
Based on everything you learned from Chapter 1 to 4, write down as many correct, distinct, and relevant facts you can about:
251 kg Te-120 at the temperature of –22 °C (density of Te is 6.24 g/cm^3)
You'll receive two points for each statement. Six statements will get you full credit for the problem.

Exam 1:
Based on everything you learned from Chapter 1 to 5, write down as many correct, distinct and relevant facts you can about:
61.6 kg $Al_2(SO_4)_3$
You'll receive 2 points for each statement. Six statements will get you full credit for the problem.

Matched questions for control group:
1. What is the formula mass for B_2Cl_4?
   A. 234.34 amu. B. 127.98 amu C. 198.89 amu. D.163.43 amu E. none of the above
2. What is the name of this compound B_2Cl_4?

3. Convert 61.6 kg into grams.
4. If the density of ethanol is 0.789 g/cm^3, what volume would 403 grams of ethanol occupy?

Group activity 2:
Based on everything you learned from Chapter 1 to 8, write down as many correct, distinct and relevant facts you can about:

107.87g $AgNO_3$ (aq) reacts with 36.46 g HCl (aq)

You'll receive 3 point for each statement. Six statements will get you full credit for the problem.

Exam 2:
Based on everything you learned from Chapter 1 to 9, write down as many correct, distinct and relevant facts you can about:

710.05 g of aqueous sodium sulfate reacts with aqueous 2.0 moles of lead(II) chloride

You'll receive 2 points for each statement. Six statements will get you full credit for the problem.

Matched questions for control group:
Write a molecular equation for aqueous sodium sulfate reacting with aqueous plumbous nitrate. Then calculate how many formula units of plumbous nitrate are needed to react with 3.29 mol of sodium sulfate.

Group activity 3:
Based on everything you learned from Chapter 1 to 11, write down as many correct, distinct, and relevant facts you can about:

0.41 mol of aqueous HBr reacts with excess calcium, producing H_2 and $CaBr_2$. This reaction occurs at 1.61 atm and at 45 degrees Celsius.

You'll receive two points for each statement. Seven statements will get you full credit for the problem.

Exam 3:
Based on everything you learned from Chapter 1 to 12, write as many distinct, accurate, and relevant statements you can for:

2.00 mol of CH_4 (l) is placed in a 120.0 L container containing O_2 at 1.00 atm and -170. 0°C. When the container is heated to 25 °C, CH_4 (g) can react with O_2 (g). CH_4 boils at -164.0 °C, and ΔH_{vap} = 8.17 kJ/mol. c_{liquid}=52.93 J/(mol °C) c_{gas} = 35.69 J/(mol °C).

You'll receive two points for each correct statement. Six statements will get you full credit for the problem.

Matched questions for control group:
Use the following data to answer the following questions.

	Methane (CH_4)	Oxygen
ΔH_{fus} (kJ/mol)	1.10	0.444
ΔH_{vap} (kJ/mol)	8.17	6.82
C_{liquid} (J/mol°C)	52.93	53.28
C_{gas} (J/mol°C)	35.69	29.378

1. How much energy is required to completely boil 2.00 moles of methane?
2. What type of intermolecular force does methane undergo?
3. How much energy is required to change the temperature of 2.00 moles of methane from -164 °C to 25 °C? It is a gas the entire time.

4. How many moles of oxygen are present if there are 5.00 atm at 25 °C in a 120.0 L tank?
5. What are the products if methane and oxygen react?
6. Draw the Lewis structure of oxygen.

Group activity 4:
Based on everything you learned from Chapter 1 to 15, write down as many correct, distinct and relevant facts you can about:

$$N_2\,(g) + H_2\,(g) \rightleftharpoons NH_3\,(g)$$

At a certain temperature, the equilibrium constant for this reaction is 6.00 x $10^{-2}M^{-2}$. The equilibrium concentrations of nitrogen and ammonia are 0.080 M and 0.13 M, respectively, and the reaction is taking place in a 5.00 L container.
You'll receive 2 points for each statement. Seven statements will get you full credit for the problem.

Exam 4:
Based on everything you learned from Chapter 1 to 15, write down as many correct, distinct and relevant facts you can about:
125 mL of 2.50 M hydrochloric acid reacts with 5.00 grams of sodium hydroxide. This reaction produces 37.34 kJ of heat.
You'll receive 2 points for each statement. Seven statements will get you full credit for the problem.

Matched questions for control group:
1. How many moles of HCl are present in 125 mL of 2.50 M HCl?
2. How many moles of NaOH are present in 5.00 grams of NaOH?
3. If the HCl from problem 1 and NaOH from problem 2 are mixed, which one will be the limiting reactant?
4. If 37.34 kJ of energy are released from the reaction in problem 3, what is the ΔH for the reaction?
5. What would be the pH of the solution resulting from problem 3?
6. What is the balanced reaction for problem 3?
7. What is the OH^- concentration of the solution resulting from problem 3?

Extra credit:
Based on everything you learned from this course, write down as many correct, distinct and relevant facts you can about:
250.0 grams of uranium-235 are placed in a reactor. A nucleus of uranium-235 absorbs a neutron and undergoes nuclear fission to produce barium-141 and krypton-92. A single atom's fission produces 211.3 MeV of energy. 1 MeV = 1.60218 x 10-13 Joules.

You will receive 2 points for each statement. Seven statements will get you full credit for this assignment.

Matched questions for control group:

1. How many atoms of uranium-235 are present in 250.0 grams of uranium-235?
   (hint: atomic mass of an isotope = the mass number)

2. If the fission of one atom of uranium-235 produces 211.3 MeV of energy, and if 1 MeV = 1.60218×10^{-13} J, how much energy will be released by 250.0 grams of uranium-235?
3. Write a reaction for the fission of uranium-235 after it is hit by a neutron if barium-141 and krypton-92 are two of the products.

Appendix 2 Code list for generating visual maps

Major topics	Concepts	Major topics	Concepts
1. Units/Sig.Fig.	Scientific notation		Classification of matter by composition *classify substances as element or compound belong to here
	Decimal part		-Pure substance
	Exponential part		-Element
	Significant figures		-Compound
	Uncertainty		-Mixture
	Rules of significant figures		-Homogenous mixture
	Exact numbers		-Heterogeneous mixture
	Rounding numbers		Property
	Significant figures in calculations		-Physical property
	-Multiplication and Division		-Chemical property
	-Addition and Subtraction		Physical change
	-Both +,=,x, ÷		Chemical change
	International system (SI)		Law of conservation of mass
	SI base units (m, kg, s, K)	**3. Energy**	Work
	Prefix multipliers		Energy
	Derived units		-Kinetic energy
	Volume		-Potential energy
	Unit conversion		-Thermal energy
	-from one to another		-Electrical energy
	-multistep		-Chemical energy
	-in both the numerator and denominator		Law of conservation of energy
	-with units raised to a power		Exothermic
	Units of energy and conversion		Endothermic
	--(J, cal, Cal, kWH)		Heat
	Conversion between T scales (°F, °C, K)		System
	Conversion factors		Surroundings
	Density = mass/volume		Absolute zero
2. Matter	Three states of matter: solid,liquid,gas		Specific heat capacity
	Solid		$q = cm\Delta T$
	Crystalline		
	Amorphous		
	Liquid		
	Gas		
	Compressible		

Major topics	Concepts	Major topics	Concepts
4. Atoms	Atom		-Metalloid
	Atomic theory		Main-group elements
	Plum-pudding model of the atom		Transition metals
	Nuclear theory of the atom		Period
	Electrical Charge		Group/ Family
	Nucleus		-Alkali metals
	-Neutron		-Alkaline earth metals
	Electron		-Halogens
	Bohr model		-Noble gases
	Orbital	**6. Compounds**	Chemical formula (type, #, order)
	Principal quantum number (n, shell)		Subscripts in chemical formula (ratio of atoms)
	Subshell (s,p,d,f)		Types of chemical formula
	Ground state		-empirical formula
	Excited state		-molecular formula
	Electron spin		-structural formula
	Pauli exclusion principle		Molecular models
	Hund's rule		-ball-and stick model
	Electron configuration		-space-filling model
	Orbital diagram		-compounds: ionic or molecular
	Valence electron		Writing formula for ionic compound
	Isotopes and symbols		Ions
	Percent natural abundance		-Cations
	Isotope symbols		-Anions
	Mass number (A)		Ion charge
5. Elements	Atomic mass (amu); name of element		Polyatomic ions (formula, name and charge)
	-elements: atomic or molecular	**7. Nomenclature**	-ionic compound
	Periodic trend		Binary: Type I or Type II
	-Atomic size		Containing polyatomic ions
	-Metallic character		-molecular compound
	-Ionization energy		-acid
	Atomic number (Z)		binary
	Chemical symbol		oxyacids (oxyanions)
	Periodic table		oxyacids (oxyanions)
	-Metal		
	-Nonmetal		

Major topics	Concepts	Major topics	Concepts
8. Composition	Avogadro's number		Spectator ion
	Mole (mole ratio)		Classifying chemical reaction
	Molar mass		-Precipitation reaction (precipitate)
	For an element -find molar mass from the periodic table -convert between grams and moles -convert between moles and # of atoms -convert between grams and # of atoms		-Acid-base (neutralization) reactions
			-Gas evolution reactions
			-Oxidation-reduction (redox) reaction
			--Combustion reaction
			Classifying chemical reactions by what atoms do
	For a compound -calculate molar mass -convert between grams and moles -convert between moles and # of atoms -convert between grams and # of atoms		- Synthesis or combination reaction
			- Decomposition reaction
			-Single-displacement reaction
			-Double-displacement reaction
			Oxidation numbers
			oxidizing agent/reducing agent
	Convert between a compound and a constituent element	**10. Stoichiometry**	Stoichiometry
	-moles to moles		Mole-to-mole
	-grams to grams		Mole-to-mass
	Mass percent		Mass-to mass
	-calculate based on mass or chemical formula		Limiting reactant
	-use it as conversion factor		Theoretical yield
9. Reactions	Evidence of a chemical reaction		Actual yield
	Reactants and products		Percent yield
	States in chemical equations		Enthalpy calculation
	Coefficient in chemical equations	**11. Solutions**	Solute
	Balance chemical equations		Solvent
	Aqueous solution		Solution
	Soluble compounds		Electrolyte & Nonelectrolyte solution
	Insoluble compounds		Concentration of solution
	Solubility rules		-mass percent
	Molecular equation		-Molarity (M)
	Complete ionic equation		
	Net ionic equation		

Major topics	Concepts	Major topics	Concepts
12. Bonding	Colligative properties	**16. acid-base**	Strong acids/strong bases
	Molality		Weak acids/weak bases
	Henry's law		Buffers
	Stock solution		Henderson-Hasselbalch
	Dilution equation M1V1=M2V2		Self-ionization of water, Kw
	Solution stoichiometry		pH and pOH
	Volume-to-volume		Titrations
	Lewis Structures		Arrhenius acids/bases
	Polarity		Bronsted acids/bases (including conjugates)
	Molecular geometry		H+ and OH- calculations
	Electron geometry	**17. nuclear**	Decay series
	Electronegativity		-alpha decay
13. Intermolecular forces	London Dispersion/Van der Waal's forces		-beta decay
	Dipole interactions		-electron capture
	Hydrogen bonding		-positron emission
	Network solids		Fission
	-ionic solids		Fusion
	-covalent solids		Half-life
	-metallic solids		Radioactivity
	Boiling point/freezing point trends		
	Heat of fusion		
	Heat of vaporization		
14. Gases	Gas laws		
	PV=nRT		
	Dalton's Law		
	Partial pressure		
	Pressure volume temperature relationships		
	Ideal gas behavior		
15. equilibrium	Reversible reactions		
	Spontaneity		
	Entropy		
	Equilibrium constants		
	Gas-phase equilibria		
	Heterogeneous equilibria		
	Le châtelier's principle		
	Catalysts		

Appendix 3 Free-response survey questions and code list

<table>
<tr><td colspan="2">Survey questions:
1. Do you think Creative Exercises help you make connections among content in this class?
2. Please explain why you chose the answer for question 1.
3. How did you prepare for this type of question on exams?
4. What are the differences when you prepared this type of question versus other types of questions such as multiple-choice questions or written ones?
5. How easy did you find it to answer this type of question?
6. How does this type of question help you understand chemistry conceptually?</td></tr>
<tr><td colspan="2">Categories & Codes</td></tr>
<tr><td colspan="2">Helpful category</td></tr>
<tr><td>1. Knowledge integration</td><td>1.1 Aware of connections
1.2 Use connections
1.3 Application of knowledge (real world)</td></tr>
<tr><td>2. Conceptual Understanding</td><td>2.1 Conceptual Understanding
2.2 Deep understanding of concepts</td></tr>
<tr><td>3. Flexibility</td><td>3.1 Freedom to choose topic
3.2 Unlimited answers</td></tr>
<tr><td>4. Study habits</td><td>4.1 Study habits (frequencies and types of actions toward studying)
4.2 Motivation
4.3 Metacognition</td></tr>
<tr><td colspan="2">Unhelpful category</td></tr>
<tr><td colspan="2">1. Challenging</td></tr>
<tr><td colspan="2">2. Need more instruction or feedback</td></tr>
<tr><td colspan="2">3. Self-doubt</td></tr>
</table>