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This article is about Al(OH)3. For AlOH, see aluminium monohydroxide. Aluminium hydroxide Unit cell ball and stick model of aluminium hydroxide Systematic IUPAC name Trihydroxidoaluminium Other names Aluminic acidAluminic
hydroxideAluminium(III) hydroxideAluminium (III) hydroxideAluminium trihydroxideAluminium trihydroxideAluminiu
 PubChem CID 10176082 RTECS number BD0940000 UNII 5QB0T2IUN0 Y CompTox Dashboard (EPA) DTXSID2036405 InChI InChI=1S/Al.3H2O/h;3*1H2/q+3;;;/p-3 YKey: WNROFYMDJYEPJX-DFZHHIFOAJ SMILES [OH-].[OH-].[OH-].[Al+3]
Properties[1][2] Chemical formula Al(OH)3 Molar mass 78.003 g·mol-1 Appearance White amorphous powder Density 2.42 g/cm3, solid Melting point 300 °C (572 °F; 573 K) Solubility in water 0.0001 g/(100 mL) Solubility product (Ksp) 3×10-34 Solubility soluble in acids and alkalis Acidity (pKa) >7 Isoelectric point 7.7 Thermochemistry[3] Std
enthalpy offormation (ΔfH298) -1277 kJ·mol-1 Pharmacology[4] ATC code A02AB01 (WHO) Hazards GHS labelling: Pictograms no GHS pictograms P261, P264, P271, P280, P304+P340, P305+P351+P338, P312, P337+P313 NFPA 704 (fire diamond) 1 0 0 Flash point Non-
flammable Lethal dose or concentration (LD, LC): LD50 (median dose) >5000 mg/kg (rat, oral) Safety data sheet (SDS) External MSDS Related compounds Other anions None Related compounds Other anions None Related compounds Other anions None Related compounds Except where
otherwise noted, data are given for materials in their standard state (at 25 °C [77 °F], 100 kPa). N verify (what is YN?) Infobox references Chemical compound Aluminium hydroxide, Al(OH)3, is found as the mineral gibbsite (also known as hydrargillite) and its three much rarer polymorphs: bayerite, doyleite, and nordstrandite. Aluminium hydroxide
is amphoteric, i.e., it has both basic and acidic properties. Closely related are aluminium oxide or aluminium oxide or aluminium oxide also forms a gelatinous precipitate in water.
Al(OH)3 is built up of double layers of hydroxyl groups with aluminium ions occupying two-thirds of the octahedral aluminium hydroxide units, with hydrogen bonds between the layers. The polymorphs differ in terms of the stacking of the layers. All
forms of Al(OH)3 crystals are hexagonal [disputed - discuss]: gibbsite is also known as \alpha-Al(OH)3[8] or \alpha-Al(OH)3[
Nonetheless, both gibbsite and hydrargillite refer to the same polymorphism of aluminium hydroxide, with gibbsite used most commonly in the United States and hydrargillite is named after the Greek words for water (hydr[o-]) and clay (argillos). Aluminium hydroxide is amphoteric. In acid, it acts as a
Brønsted-Lowry base. It neutralizes the acid, yielding a salt:[9] 3 HCl + Al(OH)3 \rightarrow AlCl3 + 3 H2O In bases, it acts as a Lewis acid by binding hydroxide ions:[9] Al(OH)4] - Red mud reservoirs (this one in Stade, Germany) contain the corrosive residues from the production of aluminium hydroxide. Virtually all the aluminium
hydroxide used commercially is manufactured by the Bayer process[10] which involves dissolving bauxite in sodium hydroxide at temperatures up to 270 °C (518 °F). The waste solid, bauxite tailings, is removed and aluminium hydroxide is precipitated from the remaining solution of sodium aluminium hydroxide can be converted to
 aluminium oxide or alumina by calcination. [citation needed] The residue or bauxite tailings, which is mostly iron oxide, is highly caustic due to the Ajka alumina plant accident in 2010 in Hungary, where a dam bursting led to the drowning of nine people. An additional 122
sought treatment for chemical burns. The mud contaminated 40 square kilometres (15 sq mi) of land and reached the Danube. While the mud was considered non-toxic due to low levels of heavy metals, the associated slurry had a pH of 13.[11] Aluminium hydroxide finds use as a fire retardant filler for polymer applications. It is selected for these
applications because it is colorless (like most polymers), inexpensive, and has good fire retardant properties.[12] Magnesium hydroxide and mixtures of huntite and hydroxide 
hydroxide used), absorbing a considerable amount of heat in the process and giving off water vapour. The decomposition rate at 250 °C (482 °F).[18] In addition to behaving as a fire retardant, it is very effective as a smoke suppressant in a wide range
of polymers, most especially in polyesters, acrylics, ethylene vinyl acetate, epoxies, polyvinyl chloride (PVC), rubber, [19] as well as in wood-based products. [20][21][22] Aluminium hydroxide is a feedstock for the manufacture of
other aluminium compounds: calcined aluminium sulfate, polyaluminium sulfate, polyaluminium chloride, activated aluminium hydroxide forms gels, which are the basis for the application of aluminium sulfate, polyaluminium sulfate, activated aluminium hydroxide forms gels, which are the basis for the application of aluminium sulfate, activated aluminium hydroxide forms gels, which are the basis for the application of aluminium sulfate, activated aluminium hydroxide forms gels, which are the basis for the application of aluminium sulfate, activated aluminium hydroxide forms gels, which are the basis for the application of aluminium hydroxide forms gels, which are the basis for the application of aluminium hydroxide forms gels, which are the basis for the application of aluminium hydroxide forms gels, which are the basis for the application of aluminium hydroxide forms gels, which are the basis for the application of aluminium hydroxide forms gels, which are the basis for the application of aluminium hydroxide forms gels, which are the basis for the application of aluminium hydroxide forms gels, which are the basis for the application of aluminium hydroxide forms gels, which are the basis for the application of aluminium hydroxide forms gels, which are the basis for the application of aluminium hydroxide forms gels, which are the basis for the application of aluminium hydroxide forms gels, which are the basis for the application of aluminium hydroxide forms gels, which are the application of aluminium hydroxide forms gels, which are the aluminium hydroxide forms gels, which are the application of aluminium hydroxide forms gels, which are the aluminium hyd
crystallizes with time. Aluminium hydroxide gels can be dehydrated (e.g. using water-miscible non-aqueous solvents like ethanol) to form an amorphous aluminium hydroxide powder, which is readily soluble in acids. Heating converts it to activated aluminas, which are used as desiccants, adsorbent in gas purification, and catalyst supports.[12] Under
the generic name "algeldrate", aluminium hydroxide is used as an antacid in humans and animals (mainly cats and dogs). It is preferred over other alternatives such as sodium bicarbonate because Al(OH)3, being insoluble, does not increase the pH of stomach above 7, and hence does not trigger secretion of excess acid by the stomach. Brand names
include Alu-Cap, Aludrox, Gaviscon or Pepsamar. It reacts with excess acid in the stomach, reducing the acidity of the stomach content, [23][24] which may relieve the symptoms of ulcers, heartburn or dyspepsia. Such products can cause constipation, because the aluminium ions inhibit the contractions of smooth muscle cells in the gastrointestinal
tract, slowing peristalsis and lengthening the time needed for stool to pass through the colon. [25] Some such products are formulated to minimize such effects through the inclusion of equal concentrations of magnesium hydroxide or magnesium hydroxide or magnesium carbonate, which have counterbalancing laxative effects. [26] This compound is also used to control
hyperphosphatemia (elevated phosphate, or phosphorus, levels in the blood) in people and animals suffering from kidney failure can cause phosphate to accumulate. The aluminium salt, when ingested, binds to phosphate in the intestines and reduce the amount of
phosphorus that can be absorbed.[27][28] Precipitated aluminium hydroxide is included as an adjuvant in some vaccines (e.g. anthrax vaccine). One of the well-known brands of aluminium hydroxide adjuvant is Alhydrogel, made by Brenntag Biosector.[29][full citation needed][dead link] Since it absorbs protein well, it also functions to stabilize
 vaccines by preventing the proteins in the vaccine from precipitating or sticking to the walls of the container during storage. Aluminium hydroxide is sometimes called "alum", a term generally reserved for one of several sulfates. [citation needed] Vaccine formulations containing aluminium hydroxide stimulate the immune system by inducing the
release of uric acid, an immunological danger signal. This strongly attracts certain types of monocytes which differentiate into dendritic cells and B cells.[30] It appears to contribute to induction of a good Th2 response, so is useful for immunizing against pathogens
that are blocked by antibodies. However, it has little capacity to stimulate cellular (Th1) immune responses, important for protection against many pathogens, [31] nor is it useful when the antigen is peptide-based. [32] In the 1960s and 1970s it was speculated that aluminium was related to various neurological disorders, including Alzheimer's disease.
[33][34] Since then, multiple epidemiological studies have found no connection between exposure to environmental or swallowed aluminium was not looked at in these studies. [35][36][37] Neural disorders were found in experiments on mice motivated by Gulf War illness (GWI). Aluminium
 hydroxide injected in doses equivalent to those administered to the United States military, showed increased reactive astrocytes, increased apoptosis of motor neurons and microglial proliferation within the spinal cord and cortex. [38] ^ For solubility product: "Solubility product constants". Archived from the original on 15 June 2012. Retrieved 17
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of aluminum hydroxide precipitated in the presence of clays", Soil Research Institute, R C Turner, Department of Agriculture, Ottawa Effect of ageing on properties of polynuclear hydroxyaluminium cations A second species of polynuclear hydroxyaluminium cations A second species of polynuclear hydroxyaluminium cations, its formation and some of its properties Retrieved from "Germain Henri Hess, in 1840,
 discovered a very useful principle which is named for him: The enthalpy of a given chemical reaction is constant, regardless of the reaction happening in one step or many steps. There is another way to use Hess' Law. It does not use the full chemical equations and it is usually presented like this: \Delta H rxno = \Sigma \Delta H fo (products) – \Sigma \Delta H fo (reactants)
                 Example #1: Calculate the standard enthalpy of combustion for the following reaction: C2H5OH(\ell) + 7/2O2(g) ---> 2CO2(g) + 3H2O(\ell) Before launching into the solution, notice I used "standard enthalpy of combustion." This is a very common that the
 phrase "standard enthalpy of combustion" is used alot and is given this symbol: ΔH°comb. The key to solving this problem is to have a table of standard enthalpies of formation handy. In case you missed it, look at the equation up near the top and see the subscripted f. What we are going to do is sum up all the product enthalpies of formation and there
 subtract the summed up reactant enthalpies of formation. Also, we need to have the equation balanced, so be sure to remember to check for that. Fractional coefficients are the coefficients and the other ones are the standard enthalpy of formation for
the four substances involved. Since oxygen is an element in its standard state, its enthalpy of formation is zero. Doing the math gives us \Delta H combo = -1367 kJ/mol of ethyl alcohol. The \Delta H fo values (-393.5, -286, -278 and zero) were looked up in a reference source. Textbooks which teach this topic will have an appendix of the values. Make sure
you find it and figure out how to use it. If you are not too clear on what the term "standard enthalpy of formation" means, please look here. Example #2: Calculate the standard enthalpy of combustion for the following ΔH fo values: C6H12O6(s)
 -1275.0~02(g) zero CO2(g) -393.5~H2O(\ell) -285.8~All the above values have units of kJ/mol because these are standard enthalpy value is the chemical reaction for the standard enthalpy of glucose: 6C(s, graphite) + 6H2(g) + 3O2(g) --> C6H12O6(s) Each standard enthalpy value is
 associated with a chemical reaction. The reaction will always form one mole of the target substance (glucose in the example) in its standard state. Note how the standard state for carbon is graphite, not diamond or buckerministerfullerene. Remember also that
enthalpy of formation is zero. Doing the math gives us \Delta H combo = -2801 kJ/mol of glucose. Example #3: Calculate the standard enthalpy of formation for glucose, given the following values: \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H combo = -280.8 kJ/mol \Delta H f, \Delta H com
glucoseo) + (6) (0) ] Did you see what I did? All the enthalpies of formation are on the right-hand side and the ΔH combo goes on the left-hand side. By the way, this is a common test question. Be prepared. Here's what happened: 1) First of all, this is the reaction we want an answer for: 6C(s, graphite) + 6H2(g) + 3O2(g) ---> C6H12O6(s) We know
> H2O(\ell) 3) Flip the first reaction and multiply the other two by six. Then add the three reactions together. If you do it right, you should recover the reaction mentioned just above in (1). Example #4: Complete combustion of 1.00 mol of acetone (C3H6O) liberates 1790 kJ. C3H6O(\ell) + 4O2(g) ---> 3CO2(g) + 3H2O(\ell) \DeltaH combo = -1790 kJ Using this
 information together with the data below (values in kJ/mol), calculate the enthalpy of formation of acetone. \Delta H f, CO2o = -393.5 \Delta H f, reactantso 2) Sustitute values into equation: -1790 = [(3)(-393.5) + (3)(-285.83)] - [(\Delta H f, acetoneo ) + (4) (0) ]
 -1790 = -2037.99 - \Delta H^{\circ}f, acetoneo \Delta H^{\circ}f
C6H14(\ell)-4163.0 C(s, gr)-393.5 H2(g)-285.8 Solution using enthalpy of combustions: 1) The enthalpy of combustion for hexane, carbon and hydrogen are these chemical equations: C6H14(\ell) + 19/202(g) ---> H2O(\ell) \DeltaH o = -393.5 kJ H2(g) + 1/202(g) ---> H2O(\ell) \DeltaH o = -393.5 kJ H2(g) + 1/202(g) ---> H2O(\ell) \DeltaH o = -285.5 kJ 2)
To obtain the target reaction (the enthalpy of formation by 6 c) multiply the second equation by 7 3) After doing that, we obtain: C6H14(\ell) + 19/2O2(g) ---> 6CO2(g) + 7H2O(\ell) \DeltaH o = +4163.0 kJ 6C(s, gr) + 6O2(g) \DeltaH o = -2361.0 kJ
7H2(g) + 7/2O2(g) ---> 7H2O(\ell) \Delta H o = -2000.6 kJ By the way, the second equation (presented as the enthalpy of combustion of hydrogen gas) is also the formation equation for the formation of carbon dioxide. The third equation (presented as the enthalpy of combustion of hydrogen gas) is also the formation for the formation for the formation of carbon dioxide.
 story? Sometimes terms overlap. The -393.5 value is the enthalpy for the combustion of carbon. It is also the formation enthalpy for carbon dioxide. 4) Adding the above three equations gives us the equation for the formation of hexane. Add the enthalpies to obtain the enthalpy of formation for hexane:: 6C(s) + 7H2(g) ---> C6H14(\ell) \Delta H o = -198.6
kJ Solution using enthalpies of formation: 1) Write the combustion reaction for hexane: C6H14(\ell) + 19/2O2 ---> 6CO2(g) + 7H2O(\ell) 2) State Hess' Law using standard enthalpies of formation: \DeltaH rxno = \Sigma \DeltaH f, reactantso 3) We note that the enthalpies of combustion for CO2(g) and H2O(\ell) are also their enthalpies of formation. We
 insert data into Hess' Law: -4163.0 = [(6) (-393.5) + (7) (-285.8)] - [(1) (\Delta H f, C6H14o) + (19/2) (0)] Note the enthalpy of formation for O2(g). Note how the enthalpy of formation for O2(g). Note how the enthalpy of formation for O2(g).
C6H14o = -198.6 \text{ kJ} Example #6: Ammonia reacts with oxygen to form nitrogen dioxide and steam, as follows: 4NH3(g) + 7O2(g) + 6H2O(g) Given the following standard enthalpies of formation (given in kJ/mol), calculate the enthalpy of the above reaction: NH3(g) - 45.90 \text{ NO2}(g) + 33.1 \text{ H2O}(\ell) - 241.83 \text{ Note that water} is given as a gas
The usual problem of this type uses water as a liquid. Not in this one. Solution: Use Hess' Law: \Delta H rxno = -1134.98 kJ = -1135 kJ Note that the units kJ/mol are NOT used. Example #7: The standard enthalpy change, \Delta H^{\circ}, for the thermal decomposition of silver nitrate according to
are left with the formation equation for AgNO2(s), the equation given in step 2. Note that the two data equations did not require any modification (flipping or multiplying by a factor). Example #8: Using standard enthalpies of formation, calculate the heat of combustion per mole of gaseous water formed during the complete combustion of ethane gas.
The enthalpies of formation needed are: C2H6(g)-84.68 O2 (g)0 CO2 (g)-393.5 H2O (g)-241.8 Solution: 1) The balanced equation for the combustion of C2H6 (ethane) is: C2H6(g)-84.68 O2 (g)0 CO2 (g)-393.5 H2O (g)-241.8 Solution: 1) The balanced equation for the combustion of Products C2H6(g)-84.68 O2 (g)0 CO2 (g)-393.5 H2O (g)-241.8 Solution: 1) The balanced equation for the combustion of Products C2H6(g)-84.68 O2 (g)0 CO2 (g)-393.5 H2O (g)-3
(-393.5 \text{ kJ/mole}) + (6 \text{ moles H2O}) (-241.8 \text{ kJ/mole}) - [(2 \text{ moles C2H6}) (-84.68 \text{ kJ/mole})] - [(3 \text{ moles H2O}) (-84.68 \text{ kJ/mole}
 I2 ---> IF5 + 2IF In addition, these two standard enthalpies of formation are known: IF7 = -941 kJ IF5 = -840 kJ Determine the \DeltaH fo for IF. Solution #1: 1) The enthalpies of formation of reactants] 2) Inserting values into the above, we find: -89 = [(-840)(1) + (2x)]
 -[(-941)(1) + (0)(1)] - 89 = 101 + 2x 2x = -190 x = -95 k Solution #2: 1) Here are all three data reactions written out in equation form: 1/2I2 + 7/2F2 ---> IF7\Delta H fo = -941 k Solution #2: 1) Here are all three data reactions written out in equation form: 1/2I2 + 1/2F2 ---> IF7\Delta H fo = -941 k Solution #2: 1) Here are all three data reactions written out in equation form: 1/2I2 + 1/2F2 ---> IF7\Delta H fo = -941 k Solution #2: 1) Here are all three data reactions written out in equation form: 1/2I2 + 1/2F2 ---> IF7\Delta H fo = -941 k Solution #2: 1) Here are all three data reactions written out in equation form: 1/2I2 + 1/2F2 ---> IF7\Delta H fo = -941 k Solution #2: 1) Here are all three data reactions written out in equation form: 1/2I2 + 1/2F2 ---> IF7\Delta H fo = -941 k Solution #2: 1) Here are all three data reactions written out in equation form: 1/2I2 + 1/2F2 ---> IF7\Delta H fo = -941 k Solution #2: 1) Here are all three data reactions written out in equation form: 1/2I2 + 1/2F2 ---> IF7\Delta H fo = -941 k Solution #2: 1) Here are all three data reactions written out in equation form: 1/2I2 + 1/2F2 ---> IF7\Delta H fo = -941 k Solution #2: 1) Here are all three data reactions written out in equation form: 1/2I2 + 1/2F2 ---> IF7\Delta H fo = -941 k Solution #2: 1) Here are all three data reactions written out in equation form: 1/2I2 + 1/2F2 ---> IF7\Delta H fo = -941 k Solution #2: 1) Here are all three data reactions written out in equation form: 1/2I2 + 1/2F2 ---> IF7\Delta H for = -941 k Solution #2: 1) Here are all three data reactions written out in equation form: 1/2I2 + 1/2F2 ---> IF7\Delta H for = -941 k Solution #2: 1) Here are all three data reactions written out in equation form: 1/2I2 + 1/2F2 ---> IF7\Delta H for = -941 k Solution #2: 1) Here are all three data reactions where 1/2I2 + 1/2F2 ---> IF7\Delta H for = -941 k Solution 1/2I2 + 1/2F2 ---> IF7\Delta H for = -941 k Solution 1/2I2 + 1/2F2 ---> IF7\Delta H for = -941 k Solution 1/2I2 + 1/2F2 ---> IF7\Delta H for = -941 k Solution 1/2I2 + 1
three data equations together in such a way as to recover the target equation 2 c) leave equation 3 untouched. 3) The result of the above is this: I2 + F2 ---> 2IF and \Delta H = -941 + (+840) + (-89) = -190 \text{ kJ} 4) However, this is not the enthalpy of formation, since that value is always for one mole of the
 product. This is the answer: \Delta Hf = -190 / 2 = -95 \text{ kJ} Example #10: What is the enthalpy change for the following reaction? SiCl4(\ell); -687 \text{ kJ} mol<sup>-</sup>1 HCl(g); -92 \text{ kJ} mol<sup>-</sup>1 Solution: \Delta H = [0 + (4) (-92)] - [-687 + (2) (0)] The zeros are the enthalpies for H2 and
Si. These are elements in their standard sate and in that case, the enthalpy of formation is always zero. \Delta H = +319 \text{ kJ} Example #11: The combustion of ethylene glycol is shown: (CH2OH)2(\ell) + 5/2O2(g) + 3H2O(\ell); \Delta H^{\circ} = -1191 \text{ kJ/mol} Determine the standard enthalpy of formation for ethylene glycol. Solution: 1) The first thing to do is
 look up standard enthalpies of formation for the other three substances involved: oxygen ---> -285.83 kJ/mol (source) 2) Next, we write Hess' Law in the form that uses standard enthalpies of formation: \Delta H rxno = \Sigma \Delta H fo (products) - \Sigma \Delta H fo (reactants) 3) And then, we put in
 + H2(g) ---> CH4(g) + HBr(g) \DeltaH° = -73.60 kJ Solution: 1) The first thing to do is write the formation equations that will include them. Since we are discussing formation equations, let's go look up their hardward for methyl bromide: C(s, gr) + 3/2H2(g) + 1/2Br2(\ell) ---> CH3Br(g) 2) Since CH4(g) and HBr(g) do not appear in the final answer, we need equations that will include them.
 formation enthalpies: C(s, gr) + 2H2(g) ---> CH4(g) \Delta H fo = -74.87 kJ (found here) 1/2H2(g) \Delta H fo = -36.29 kJ (found here) 3) Use Hess' Law: CH4(g) + HBr(g) ---> CH4(g) \Delta H fo = -74.87 kJ 1/2H2(g) \Delta H fo = -36.29 kJ Note that the
first equation was reversed. Nothing was done to the enthalpies to obtain: \Delta H fo = -37.56 kJ/mol Data for methyl bromide may be found here. Example #13: Use Hess' Law to calculate the enthalpy of vaporization for ethanol,
C2H5OH: C2H5OH(\ell) ---> C2H5OH(g) Solution: enthalpy of formation, gas ---> -234 kJ/mol enthalpy of formation, liquid ---> -276 kJ/mol Example #14: Use standard enthalpies of formation to calculate the enthalpy change (in kJ) for the
reduction of iron(III) oxide to iron at 298 K and 1 atm. (Calculate it for the reaction as written, namely 2 moles of carbon.) 2Fe2O3(s) + 3C(s) ---> 4Fe(s) + 3CO2(g) Solution: 1) Let us assume that the carbon is in its standard state of graphite (as opposed to diamond or buckminsterfullerene). That means: ΔH f, carbono =
0 \Delta H f, irono = 0 2) We must look up the standard enthalpy of formation for the other two substances: \Delta H f, Fe2O3o = -825.50 \text{ kJ/mol} (source) \Delta H f, reactantso 4) Sustitute values into equation: \Delta H rxno = [(3) (-393.51 \text{ kJ/mol} (source) \Delta H f, Fe2O3o = <math>-825.50 \text{ kJ/mol} (source) \Delta H f, Fe2O3o = -825.50 \text{ kJ/mol} (source) \Delta H f, reactantso 4) Sustitute values into equation: \Delta H rxno = [(3) (-393.51 \text{ kJ/mol} (source) \Delta H f, Fe2O3o = <math>-825.50 \text{ kJ/mol} (source) \Delta H f, reactantso 4) Sustitute values into equation: \Delta H rxno = [(3) (-393.51 \text{ kJ/mol} (source) \Delta H f, Fe2O3o = <math>-825.50 \text{ kJ/mol} (source) \Delta H f, reactantso 4) Sustitute values into equation: \Delta H rxno = [(3) (-393.51 \text{ kJ/mol} (source) \Delta H f, Fe2O3o = <math>-825.50 \text{ kJ/mol} (source) \Delta H f, reactantso 4) Sustitute values into equation: \Delta H rxno = [(3) (-393.51 \text{ kJ/mol} (source) \Delta H f, Fe2O3o = <math>-825.50 \text{ kJ/mol} (source) \Delta H f, reactantso 4) Sustitute values into equation: \Delta H rxno = [(3) (-393.51 \text{ kJ/mol} (source) \Delta H f, Fe2O3o = <math>-825.50 \text{ kJ/mol} (source) \Delta H f, reactantso 4) Sustitute values into equation: \Delta H rxno = [(3) (-393.51 \text{ kJ/mol} (source) \Delta H f, Fe2O3o = <math>-825.50 \text{ kJ/mol} (source) \Delta H f, reactantso 4) Sustitute values into equation: \Delta H rxno = [(3) (-393.51 \text{ kJ/mol} (source) \Delta H f, Fe2O3o = <math>-825.50 \text{ kJ/mol} (source) \Delta H f, reactantso 4) Sustitute values into equation: \Delta H rxno = [(3) (-393.51 \text{ kJ/mol} (source) \Delta H f, Fe2O3o = <math>-825.50 \text{ kJ/mol} (source) \Delta H f, reactantso 4) Sustitute values into equation: \Delta H rxno = [(3) (-393.51 \text{ kJ/mol} (source) \Delta H f, Fe2O3o = <math>-825.50 \text{ kJ/mol} (source) \Delta H f, reactantso 4) Sustitute values into equation: \Delta H rxno = [(3) (-393.51 \text{ kJ/mol} (source) \Delta H f, Fe2O3o = (393.51 \text{ kJ/mol} (source) \Delta H f, Fe2O3o = (393.51 \text{ kJ/mol} (source) \Delta H f, Fe2O3o = (393.51 \text{ kJ/mol} (source) \Delta H f, Fe2O3o = (393.51 \text{ kJ/mol} (source) \Delta H f, Fe2O3o = (393.51 \text{ kJ/mol} (source) \Delta H f, Fe2O3o = (393.51 \text{ kJ/mol} (source) \Delta H f, Fe2O3o = (393.51 \text{ kJ
ΔH rxno = 470.47 kJ Note: Do not write kJ/mol. The kJ produced are for the reaction as written. In other words, 470.47 kJ are produced when two moles of formation to determine the enthalpy of reaction for: 2H2O(ℓ) + 2SO2(g) ---> 2H2S(g) + 3O2(g)
 Solution: 1) Since the example does not provide enthalpy of formation values, we must look them up. The ChemTeam uses the NIST Chemistry WebBook: \Delta H f, H_{20} = -285.83 kJ/mol (source) \Delta H f, \Delta H_{20} = -285.83 kJ/mol (source) \Delta H_{20} = 
productso -\Sigma ΔH f, reactantso 3) Put values in place and solve: ΔH rxno = (-285.83 \text{ kJ/mol}) - (2 \text{ mol}) (-285.83 \text{ kJ/mol}) + (2 \text{ mol}) (-285.8
search. If you look at any of the examples, be aware that the enthalpy values are often going to be slightly different than the ones I used above. Example #16: What is being asked for is the enthalpy for this reaction: H2O($\ell$) ---> H2O($g$) 2) We can get to the above
reaction by using formation equations for H2O(\ell) and H2O(g). Here are the chemical equations: (a) H2(g) + 1/2O2(g) ---> H2O(\ell) (b) H2(g) + 1/2O2(g) ---> H2O(\ell) (b) H2(g) + 1/2O2(g) ---> H2O(\ell) (c) H2(g) + 1/2O2(g) ---> H2O(\ell) (d) H2(g) + 1/2O2(g) ---> H2O(\ell) (e) H2(g) + 1/2O2(g) ---> H2O(\ell) (e) H2(g) + 1/2O2(g) ---> H2O(\ell) (found here) (e) H2(g) + 1/2O2(g) ---> H2O(\ell) (found here) (e) H2(g) + 1/2O2(g) ---> H2O(\ell) (found here) (found 
 liquid water on the left-hand side of the reaction arrow: H2O(\ell) ---> H2O(g) \Delta H o = +24.00 kJ 6) This just-calculated value is the enthalpy of
 vaporization at standard conditions. The value most commonly used (40.7 kJ/mol) in thermochemistry problems is the enthalpy of vaporization at 100 °C. Bonus Example: Given the following information: \DeltaH fo kJ/mol Li2O(s)597.9 Li+(aq)-278.5 Na2O(s)-416 Na+(aq)-240 K2O(s)-361 K+(aq)-251 CO(g)-110.5 CO2(g)-393.5 H2O(\ell
 -286~\mathrm{OH}^-(\mathrm{aq}) - 230~\mathrm{CCl4}(\ell) - 135~\mathrm{SiO2}(\mathrm{s}) - 911~\mathrm{LiCl}(\mathrm{s}) - 409~\mathrm{NaCl}(\mathrm{s}) - 436~\mathrm{Cl}^-(\mathrm{aq}) - 167~\mathrm{Calculate}~\Delta H for the following reaction: 2\mathrm{Li}(\mathrm{s}) + 2\mathrm{H2O}(\ell) - --> 2\mathrm{Li} + (\mathrm{aq}) + 2\mathrm{OH}^-(\mathrm{aq}) = 2\mathrm{LiOH}(\mathrm{aq}) + 2\mathrm{H2O}(\ell) - --> 2\mathrm{Li} + (\mathrm{aq}) + 2\mathrm{OH}^-(\mathrm{aq}) = 2\mathrm{LiOH}(\mathrm{aq}) + 2\mathrm{H2O}(\ell) - --> 2\mathrm{LiOH}(\mathrm{aq}) + 2\mathrm{H2O}(\ell) + 2\mathrm{H2O}
2H2O(\ell) ---> 2Li+(aq) + 2OH^-(aq) + H2(g) 3) We need the following reactions: Li(s) ---> Li+(aq) + e^-\Delta H = -278.5 kJ/mol e^- + 1/2H2(g) + 1/2O2(g) ---> 2Li+(aq) + 2OH^-(aq) + H2(g) 5) Use Hess' Law utilizing the revised target equation: \Delta H = [(2)(-278.5) + (24.5)(-278.5)]
(2)(-230) + (0)] - [(2)(0) + (2)(-286)] \Delta H = -445 \text{ kJ} A pure substance is the most stable form of the substance in aqueous solution, is a concentration of 1.00 M and for a gas the pressure is 1 atm. The standard enthalpy
 there are two moles of NaCl. Formation equations are always written in terms of 1 mole of product. 2 Na (s) + Cl2 (g) \rightarrow 2 NaCl (s) This is not a formation equation when all substances are in their standard enthalpy of formation for the
 following formation reaction is -411.2 kJ/mol. Na (s) + 1/2 Cl2 (g) \rightarrow NaCl (s) \triangle Hof = -411.2 kJ/mol Values of \triangleHof, can be found in tables or in the CRC Handbook of Chemistry and Physics. Click to see a table of thermodynamic quantities. The \triangleHof, values for elements in their most stable state are zero. For our reaction, \triangleHof, for both Na (s) and
Cl2 are zero as both are elements in their standard states. The value for 1 mole of NaCl is -411.2 kJ/mol. In this example, we are asked to write a formation equation for liquid ethanol, CH3CH2OH. Recall, the formation equation is for 1 mole of a substance formed from its elements are C (graphite), H2 (g), and O2 (g) C (graphite) + H2
(g) + O2(g) \rightarrow CH3CH2OH(l) Next, balanced formation while keeping in mind there can only be 1 mole of ethanol in the balanced formation reaction. The balanced formation while keeping in mind there can only be 1 mole of ethanol in the balanced formation reaction. The balanced formation while keeping in mind there can only be 1 mole of ethanol in the balanced formation reaction. The balanced formation while keeping in mind there can only be 1 mole of ethanol in the balanced formation reaction. The balanced formation while keeping in mind there can only be 1 mole of ethanol in the balanced formation reaction.

ightharpoonup CH3CH2OH (l) 
ightharpoonup AHof = -277.7 kJ/mol We can calculate 
ightharpoonupHof values for each substance in the equation, multiplying each value by the equation. Sum the product standard enthalpies of formation, multiplying each value by the equation coefficient for that substance. Then sum the reactant standard enthalpies of formation, multiplying each value by the equation.
 value by the equation coefficient for that substance. Subtract the values for the reactants from the products: \DeltaHorxn = \sum m \DeltaHof (products) - \sum n \DeltaHof (products) - \sum n \DeltaHof (products) and reactants). The values of m and n are the coefficients of the products and reactants.
Go to the table to look up the \DeltaHof values for each reactant and product. \DeltaHof [CO2 (g)] = -393.5 kJ/mol \DeltaHof [CO2 (g)] = -241.8 kJ/mol \DeltaHof [CO2 (g)] = -241.8 kJ/mol \DeltaHof [CO2 (g)] = -241.8 kJ/mol \DeltaHof [CO2 (g)] = -393.5 kJ/mol \DeltaHof [CO2 (g)] = -241.8 kJ/mol \DeltaHof [CO2 (g)] = -393.5 kJ/mol \DeltaHof [CO2 (g)] = -39
 H \{rxn\}\;=\\;[k]\}\{mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol\}\;+\;10\;mol}\;+\;10\;mol\}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10\;mol}\;+\;10
the combustion of one mole of butane, divide equation coefficients and ΔHorxn by 2, there would be 2657 J of heat released. Worksheet: Heats of Formation at 25 °C Exercises Exercise 2. What is the value of ΔHof for LiOH (s)? Write a formation for LiOH (s). Exercise 3. Calculate ΔHorxn by 2, there would be 2657 J of heat released. Worksheet: Heats of Formation at 25 °C Exercises Exercise 3. Calculate ΔHorxn by 2, there would be 2657 J of heat released. Worksheet: Heats of Formation at 25 °C Exercises Exercise 3. Calculate ΔHorxn by 2, there would be 2657 J of heat released. Worksheet: Heats of Formation at 25 °C Exercises Exercise 3. Calculate ΔHorxn by 2, there would be 2657 J of heat released. Worksheet: Heats of Formation at 25 °C Exercises Exercise 3. Calculate ΔHorxn by 2, there would be 2657 J of heat released. Worksheet: Heats of Formation at 25 °C Exercises Exercise 3. Calculate ΔHorxn by 2, there would be 2657 J of heat released. Worksheet: Heats of Formation at 25 °C Exercises Exercise 3. Calculate ΔHorxn by 2, there would be 2657 J of heat released. Worksheet: Heats of Formation at 25 °C Exercises Exercise 3. Calculate ΔHorxn by 2, there would be 2657 J of heat released. Worksheet: Heats of Formation at 25 °C Exercises Exercise 3. Calculate ΔHorxn by 2, there would be 2657 J of heat released. Worksheet: Heats of Formation at 25 °C Exercises Exercise 3. Calculate ΔHorxn by 2, there would be 2657 J of heat released. Worksheet: Heats of Formation at 25 °C Exercises Exercise 3. Calculate ΔHorxn by 3. Calcula
in kJ for the following reaction. (Table of Thermodynamic Quantities) Fe2O3 (s) + 3 CO (g) \rightarrow 2 Fe (s) + 3 CO (g) \rightarrow 2 Fe (s) + 3 CO (g) \rightarrow 4 CO2 (g) \rightarrow 6 CO2 (g) + 6 H2O (g) \rightarrow 4 H2O (g) \rightarrow 5 CO2 (g) + 6 H2O (g) \rightarrow 6 CO2 (g) + 6 H2O (g) \rightarrow 7 Fe (s) + 3 CO2 (g) \rightarrow 8 CO2 (g) + 6 H2O (g) \rightarrow
 from the Table of Thermodynamic Quantities to calculate the standard enthalpy of formation, ΔHof for methylcyclopentane. Check Solutions/Answers to Exercises Back to Home Page The 20 contributors listed below account only for 75.5% of the provenance of ΔfH° of CH3CH2OH
(l). A total of 186 contributors would be needed to account for 90% of the provenance. The list is limited to 20 most important contributors or, if less, a number sufficient to account for 90% of the provenance. The list is limited to 20 most important contributors or, if less, a number sufficient to account for 90% of the provenance. The list is limited to 20 most important contributors or, if less, a number sufficient to account for 90% of the provenance.
original units; in cases where we have reinterpreted the original measurement, the listed value may differ from that given by the authors. The quoted uncertainty is the a priori uncertainty used as input when constructing the initial Thermochemical Network, and corresponds either to the value proposed by the original authors or to our estimate; if an
 additional multiplier is given in parentheses immediately after the prior uncertainty, it corresponds to the factor by which the prevailing knowledge contained in the Thermochemical Network. The standard enthalpy of
 formation is defined as the change in enthalpy when one mole of a substance in the standard enthalpy of formation is a measure of the energy released or consumed when one mole of a substance is created under standard conditions from
its pure elements. The symbol of the standard enthalpy of formation is \DeltaHf. \Delta = A change in enthalpy of formation (originating from Enthalpy's being a State Function), shown
 below, is commonly used: \[\Delta H {reaction}^o = \sum {\Delta H {f}^o(products)} - \sum {\Delta H {f}^o(p
 Example \(\PageIndex{1}\) Given a simple chemical equation with the variables A, B and C representing different compounds: \(A + B \leftrightharpoons C\) and the equation for the standard enthalpy change of formation is as follows:
 \DeltaHreactiono = \DeltaHfo[C] - (\DeltaHfo[A] + \DeltaHfo[B]) \DeltaHreactiono = (1 mol)(523 kJ/mol) - ((1 mol)(433 kJ/mol) + (1 mol)(-256 kJ/mol)) Because there is one mole each of A, B and C, the standard enthalpy of formation of each reactant and product is multiplied by 1 mole, which eliminates the mol denominator: \DeltaHreactiono = 346 kJ The result is 346 kJ, which
formation of zero. To determine which form is zero, the more stable form of carbon is chosen. This is also the form with the lowest enthalpy, so graphite has a standard enthalpy of formation of various compounds. Table 1: Sample Table of Standard Enthalpy of
 Formation Values. Table T1 is a more comprehensive table. Compound \DeltaHfo O2(g) 0 kJ/mol CO(g) -10.5 kJ/mol NO(g) 90.25 kJ/mol NO(g) 90.25 kJ/mol NO(g) 90.25 kJ/mol SO2(g) -296.8 kJ/mol SO3(g) -395.7 kJ/mol SO3(g) -395.7 kJ/mol All values have units of kJ/mol and
 physical conditions of 298.15 K and 1 atm, referred to as the "standard enthalpies of formation are exothermic, or negative, there are a few compounds such as NO(g) and N2O4(g) that
 actually require energy from its surroundings during its formation; these endothermic compounds are generally unstable. Example \(\PageIndex{2}\) Between Br2(1) and Br2(g) at 298.15 K, which means it has the lower enthalpy; thus, Br2(1) has
 AHf = 0. Consequently, Br2(g) has a nonzero standard enthalpy of formation. Note: that the element phosphorus is a unique case. The reference form, white phosphorus, Recall that standard enthalpies of formation can be either positive or negative. Example
(\PageIndex{3}\) The enthalpy of formation of CO2(g) and graphite for carbon dioxide at 298.15K is \DeltaHf = -393.5 kJ/mol CO2(g). Write the chemical equation for the formation of CO2(g) and graphite for carbon \[O {2}(g) + C(graphite) \]
\rightleftharpoons CO_{2}(g)\] The general equation for the standard enthalpy change of formation is given below: \[\Delta H_{f}^o(Reactants)}\] Plugging in the equation for the formation of CO2 gives the following: \Delta H feaction \Delta H formation for the standard enthalpy change of formation for the equation for the formation of CO2 gives the following: \Delta H formation for the equation for the formation 
Because O2(g) and C(graphite) are in their most elementally stable forms, they each have a standard enthalpies of formation equal to 0: \DeltaHreactiono= -393.5 kJ = \DeltaHfo[CO2(g)] - ((1 mol)(0 kJ/mol)) \DeltaHfo[CO2(g)] - ((1 mol)(0 kJ/m
the \DeltaHreaction for the formation of NO2(g). SOLUTION \(NO \{2\}(g)\\) is formed from the combination of \(NO \{2\}(g)\\) in the following reaction: \(\(2\)(g)\\) in the following reaction: \(\(2\)(g)\\) is formed from the combination of \(\(2\)(g)\\) in the following reaction: \(\(2\)(g)\\) is formed from the combination of \(\(2\)(g)\\) in the following reaction: \(\(2\)(g)\\) is formed from the combination of \(\(2\)(g)\\) in the following reaction: \(\(2\)(g)\\) is formed from the combination of \(\(2\)(g)\\) is formed from the combination of \(\(2\)(g)\\) in the following reaction: \(\(2\)(g)\\) is formed from the combination of \(\(2\)(g)\\) in the following reaction: \(\(2\)(g)\\) is formed from the combination of \(\(2\)(g)\\) in the following reaction: \(\(2\)(g)\\) is formed from the combination of \(\(2\)(g)\\) in the following reaction: \(\(2\)(g)\\) is formed from the combination of \(\(2\)(g)\\) in the following reaction: \(\(2\)(g)\\) is formed from the combination of \(\(2\)(g)\\) in the following reaction: \(\(2\)(g)\\) in the following reaction: \(\(2\)(g)\\) is formed from the combination of \(\(2\)(g)\\).
H \{f\}^o(products)\} - \sum \{Delta\ H\ \{f\}^o(products)\}\] The relevant standard enthalpy of formation values from Table 1 are: O2(g): 0 k]/mol NO(g): 90.25 k]/mol 
k]\cancel{mol}) + (1 \cancel{mol})\(\text{ion}\) \cancel{mol})\(\text{ion}\) \cancel{mol}\)\(\text{cancel}\) (UCD), Garrett Larimer (UCD
Periodicity8 Bonding: General Concepts9 Covalent Bonding: Orbitals10 Liquids And Solids11 Properties Of Solutions12 Chemical Kinetics13 Chemical Equilibria17 Spontaneity, Entropy, And Free Energy18 Electrochemistry19 The Nucleus: A Chemist's View20 The
Representative Elements 21 Transition Metals And Coordination Chemistry 22 Organic And Biological Molecules expand more Problem 1RQ: Define and explain the differences between the following terms. a. law and theory b. theory and ... Problem 2RQ: Is the scientific method suitable for solving problems only in the
sciences? Explain. Problem 3RQ: Which of the following pieces of glassware, provide sample measurement and discuss the number of ... Problem 5RQ: A student performed an analysis of a sample for its calcium content and got the
following results:...Problem 6RQ: Compare and contrast the multiplication/division significant figure rule to the significant figure which temperature scale (F, C. or K) docs 1 degree represent the smallest change in
temperature? Problem 9RQ: Distinguish between physical changes and chemical changes. Problem 10RQ: Why is the separation of mixtures into pure or relatively pure substances so important when... Problem 2ALQ Problem 3ALQ: a. There are 365 days per year, 24 hours per day, 12 months per year, and 60 minutes per hour. Use... Problem 2ALQ Problem 3ALQ: a. There are 365 days per year, 24 hours per day, 12 months per year, and 60 minutes per hour. Use... Problem 3ALQ: a. There are 365 days per year, 24 hours per day, 12 months per year, and 60 minutes per hour. Use... Problem 3ALQ: a. There are 365 days per year, 24 hours per day, 12 months per year, and 60 minutes per hour. Use... Problem 3ALQ: a. There are 365 days per year, and 60 minutes per hour. Use... Problem 3ALQ: a. There are 365 days per year, and 60 minutes per hour. Use... Problem 3ALQ: a. There are 365 days per year, and 60 minutes per hour. Use... Problem 3ALQ: a. There are 365 days per year, and 60 minutes per hour. Use... Problem 3ALQ: a. There are 365 days per year, and 60 minutes per hour. Use... Problem 3ALQ: a. There are 365 days per year, and 60 minutes per hour. Use... Problem 3ALQ: a. There are 365 days per year, and 60 minutes per hour. Use... Problem 3ALQ: a. There are 365 days per year, and 60 minutes per hour. Use... Problem 3ALQ: a. There are 365 days per year, and 60 minutes per hour. Use... Problem 3ALQ: a. There are 365 days per year, and 60 minutes per hour. Use... Problem 3ALQ: a. There are 365 days per year, and 60 minutes per hour. Use... Problem 3ALQ: a. There are 365 days per year, and 60 minutes per hour. Use... Problem 3ALQ: a. There are 365 days per year, and 60 minutes per hour. Use... Problem 3ALQ: a. There are 365 days per year, and 60 minutes per hour. Use... Problem 3ALQ: a. There are 365 days per year, and 60 minutes per hour. Use... Problem 3ALQ: a. There are 365 days per year, and 60 minutes per hour. Use... Problem 3ALQ: a. There are 365 days per year, and 60 minutes per year. Problem 3ALQ: a. There are 365 days per yea
When a marble is dropped into a beaker of water, it sinks to the bottom. Which of the following is...Problem 6ALQ: If you place a glass rod over a burning candle, the glass appears to turn black. What is happening...Problem
7ALQ: Which characteristics of a solid, a liquid, and a gas are exhibited by each of the following and explain: a. a...Problem 9ALQ: What is
wrong with the following statement? "The results of the experiment do not agree with the ... Problem 11ALQ: Why is it incorrect to say that the results of a measurement were accurate but not precise? Problem 15ALQ: Consider the
addition of 15.4 to 28. What would a mathematician say the answer is? What would a...Problem 16ALQ: True or false? For mathematician say the answer is? What would a mathematician say the answer is? What would a...Problem 16ALQ: Is there a
difference between a homogeneous mixture of hydrogen and oxygen in a 2:1 ratio and a...Problem 190: The difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the difference between a law and a theory is the differe
method.Problem 22QProblem 23Q: A measurement is a quantitative observation involving both a number and a unit. What is a ...Problem 25Q: What are significant figures? Show how to indicate the number one thousand to 1 significant
figure,...Problem 26Q: A cold front moves through and the temperature drops by 20 degrees. In which temperature scale would...Problem 29Q: Is the density of a gaseous substance larger or smaller than the density of a liquid or a solid
at...Problem 30Q: Give four examples illustrating each of the following terms. a. homogeneous mixture b. heterogeneous...Problem 31E: Which of the following are exact numbers? a. There are 100 cm in 1 m. b. One meter equals 1.094...Problem 32E: Indicate the number of significant figures in each of the following: a. This book contains more
than...Problem 33E: How many significant figures are there in each of the following values? a. 6.07 1015 b. 0.003840 c....Problem 34E: How many significant figures are in each of the following? a. 100 b. 102 c. 103 d. 100. e. 0.0048...Problem 35E: Round off each of the following numbers to the indicated number of significant digits, and write
the...Problem 36E: Use exponential notation to express the number 385,500 to a. one significant figure. b. two...Problem 37E: You have liquid in each graduated cylinder shown below have different precisions. a. Label the amount of water in each of the
three...Problem 39E: Evaluate each of the following, and write the answer to the appropriate number of ...Problem 41E: Perform the following mathematical operations, and express the result to the correct number of ...Problem 41E: Perform the following mathematical operations, and express the result to the correct number of ...Problem 41E: Perform the following mathematical operations, and express the result to the correct number of ...Problem 41E: Perform the following mathematical operations, and express the result to the correct number of ...Problem 41E: Perform the following mathematical operations, and express the result to the correct number of ...Problem 41E: Perform the following mathematical operations, and express the result to the correct number of ...Problem 41E: Perform the following mathematical operations, and express the result to the correct number of ...Problem 41E: Perform the following mathematical operations are not problem 41E: Perform the following mathematical operations are not problem 41E: Perform the following mathematical operations are not problem 41E: Perform the following mathematical operations are not problem 41E: Perform the following mathematical operations are not problem 41E: Perform the following mathematical operations are not problem 41E: Perform the following mathematical operations are not problem 41E: Perform the following mathematical operations are not problem 41E: Perform the following mathematical operations are not problem 41E: Perform the following mathematical operations are not problem 41E: Perform the following mathematical operations are not problem 41E: Perform the following mathematical operations are not problem 41E: Perform the following mathematical operations are not problem 41E: Perform the following mathematical operations are not problem 41E: Perform the following mathematical operations are not problem 41E: Perform the following mathematical operations are not problem 41E: Perform the following mathematical operations are not problem 41E: Perform the
42E: Perform the following mathematical operations, and express the result to the correct number of...Problem 43E: a. How many kilograms are in 1 teragram? b. How many nanometers are in 6.50 x 102 terameters? c. How...Problem 45E:
Perform the following unit conversions. a. Congratulations! You and your spouse are the proud...Problem 48E: Perform the following exact conversion factors to perform the stated calculations: 512 yd -= 1 rod 40...Problem 48E: Although the
preferred SI unit of area is the square meter, land is often measured in the English system: 24 grains 1 pennyweight...Problem 50E: Apothecaries (druggists) use the following set of measures in the English system: 20 grains ap = 1...Problem 51E: For a pharmacist
dispensing pills or capsules, it is often easier to weigh the medication to be...Problem 52E: A children's pain relief elixir contains 80. mg acetaminophen per 0.50 teaspoon. The dosage...Problem 52E: A children's pain relief elixir contains 80. mg acetaminophen per 0.50 teaspoon.
is 9.58 s. What is the corresponding average speed in...Problem 55E: You are driving 65 mi/h, how long...Problem 57E: The dosage for an antibiotic is prescribed at 8.0 mg
per kilo-gram of body weight, taken twice daily...Problem 58E: In recent years, there has been a large push for an increase in the use of renewable resources to...Problem 60E: Carbon monoxide (CO) detectors sound an alarm when peak levels of carbon monoxide reach 100 parts...Problem 61E: Convert the following Fahrenheit
temperatures to the Celsius and Kelvin scales. a. 459F, an...Problem 62E: A thermometer gives a reading of 96.1F 0.2F. What is the temperatures to Kelvin and to Fahrenheit degrees. a. the temperature...Problem 64E: Convert the following Kelvin temperatures to
Celsius and Fahrenheit degrees. a. the temperature in ... Problem 65E: At what temperature in degrees Fahrenheit equal to twice the temperature in ... Problem 67E: Use the figure below to answer the following
questions. a. Derive the relationship between C and X....Problem 68E: Ethylene glycol is the main component in automobile anti-freeze. To monitor the temperature of an...Problem 69E: A material will float on the surface of a liquid if the material has a density less than that of the...Problem 70E: One metal object is a cube with edges of 3.00 cm and a
mass of 140.4 g. A second metal object is a...Problem 71E: A star is estimated to have a mass of 2 1036 kg. Assuming it to be a sphere of average radius 7.0 ...Problem 73E: Diamonds are measured in carats, and 1 carat = 0.200 g. The
density of diamond is 3.51 g/cm3. a....Problem 74E: At room temperature the element bromine, Br2, is a liquid with a density of 5.12 g/cm3. Calculate...Problem 75E: A sample containing 33.42 g of metal pellets is poured into a graduated cylinder initially...Problem 76E: The density of pure silver is 10.5 g/cm3 at 20C. If 5.25 g of pure silver pellets is
added to a...Problem 77E: In e-ach of the following pairs, which has the greater mass? (See Table 1.5.) a. 1.0 kg of feathers...Problem 78E: a. Calculate the mass of...Problem 78E: a. Calculate the mass of ethanol in 1.50 gt of ethanol in 1.50 gt of feathers...Problem 78E: a. Calculate the mass of...Problem 78E: a. Calculate
of...Problem 80E: Using Table 1.5, calculate the volume of 25.0 g of each of the following substances at 1 atm. a....Problem 81E: The density of osmium (the denset metal) is 22.57 g/cm3. If a 1.00-kg rectangular block of osmium...Problem 81E: The density of osmium (the denset metal) is 22.57 g/cm3. If a 1.00-kg rectangular block of osmium...Problem 82E: A copper wire (density = 8.96 g/cm3) has a diameter of 0.25 mm. If a sample of this copper wire
has...Problem 83E: Match each description below with the following microscopic pictures. More than one picture may fit...Problem 85E: What is the difference between homogeneous and heterogeneous matter? Classify each of the
following...Problem 86E: Classify the following as a mixture or a pure substance. a. water b. blood c. the oceans d....Problem 88E: Suppose a teaspoon of magnesium filings and a teaspoon of powdered sulfur are placed together in
a...Problem 89E: If a piece of hard, white blackboard chalk is heated strongly in a flame, the mass of the piece of...Problem 91E: Classify the following as physical or chemical changes. a. Moth balls gradually vaporize in a...Problem
92E: The properties of a mixture are typically averages of the properties of its components. The...Problem 93AE: Two spherical objects have the same mass. One floats on water; the other sinks, Which object has the...Problem 95AE: Lipitor,
a pharmaceutical drug that has been shown to lower bad cholesterol levels while raising...Problem 96AE: In Shakespeares Richard III, the First Murderer says: Take that, and that! [Stabs Clarence] If that...Problem 96AE: In the opening scenes of the movie Raiders of the Lost Ark, Indiana Jones tries to remove a gold...Problem
99AEProblem 100AE: The active ingredient of aspirin tablets is acetylsalicylic acid, which, has a density of 1.4 g/cm3....Problem 101AE: This year, like many past years, you begin to feel very sleepy alter eating a large helping of ...Problem 101AE: This year, like many past years, you begin to feel very sleepy alter eating a large helping of ...Problem 101AE: This year, like many past years, you begin to feel very sleepy alter eating a large helping of ...Problem 101AE: This year, like many past years, you begin to feel very sleepy alter eating a large helping of ...Problem 101AE: This year, like many past years, you begin to feel very sleepy alter eating a large helping of ...Problem 101AE: This year, like many past years, you begin to feel very sleepy alter eating a large helping of ...Problem 101AE: This year, like many past years, you begin to feel very sleepy alter eating a large helping of ...Problem 101AE: This year, like many past years, you begin to feel very sleepy alter eating a large helping of ...Problem 101AE: This year, like many past years, you begin to feel very sleepy alter eating a large helping of ...Problem 101AE: This year, like many past years, you begin to feel very sleepy alter eating a large helping of ...Problem 101AE: This year, like many past years, you begin to feel very sleepy alter eating a large helping of ...Problem 101AE: This year, like many past years, you begin to feel very sleepy alter eating a large helping of ...Problem 101AE: This year, like many past years, you begin to feel very sleepy alter eating a large helping of ...Problem 101AE: This year, like many past years, you begin to feel very sleepy alter eating a large helping of ...Problem 101AE: This year, like many past years, you begin to feel very sleepy alter eating a large helping of ...Problem 101AE: This year, like many years, you begin to feel very sleepy alter eating a large helping of ...Problem 101AE: This year, you begin to feel very sleepy alter eating a large helping of ...Problem 101AE: This year, you 
b....Problem 103AE: A person with high cholesterol has 250 mg of cholesterol per 100.0 mL of blood. If the total blood...Problem 104AEProblem 105AE: A column of liquid is found to expand linearly on heating. Assume the column rises 5.25 cm for a...Problem 105AE: A column of liquid is found to expand linearly on heating. Assume the column rises 5.25 cm for a...Problem 105AE: A column of liquid is found to expand linearly on heating.
is filled to...Problem 107AE: For each of the following, decide which block is more dense; the orange block, the blue block, or it...Problem 108AE: According to the Official Rules of Baseball, a baseball must have a circumference not more than 9.25...Problem 109AE: The density of an irregularly shaped object was determined as follows. The mass of
the object was...Problem 110AE: The chemist in Example 1.14 did some further experiments. She found that the pipet used to measure...Problem 112CWP: Secretariat is known as the horse with the fastest run in the Kentucky Derby. If
Secretariats record...Problem 113CWP: The hottest temperature recorded in the United States is 134F in Greenland Ranch, CA. The melting...Problem 116CWP: Which of the following describes a chemical property? a. The
density of iron is 7.87 g/cm3. b. A...Problem 117CP: A rule of thumb in designing experiments is to avoid using a result that is the small difference...Problem 119CP: Many times errors are expressed in terms of percentage. The
percent error is die absolute value of...Problem 120CP: A person weighed 15 pennies on a balance and recorded the following masses: 3.112 g 3.109 g 3.059 g...Problem 121CP: On October 21, 1982, the Bureau of the Mint changed the composition of pennies (see Exercise 120)....Problem 122CP: As part of a science project, you study traffic patterns
in your city at an intersection in the...Problem 123CP: Sterling silver is a solid solution of silver and copper. If a piece of a sterling silver necklace...Problem 125CP: Confronted with the box shown in the diagram, you wish to discover
something about its internal...format list bulleted
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