1. The general formula of an alkane is
   A. $C_{2n}H_{2n}$  
   B. $C_{n}H_{2n}$  
   C. $C_{n}H_{n+2}$  
   D. $C_{n}H_{2n-2}$  
   E. $C_{n}H_{2n+2}$

2. Which of the following compounds is not a saturated hydrocarbon?
   A. CH$_2$CH$_2$  
   B. CH$_3$CH$_3$  
   C. CH$_4$  
   D. CH$_3$CH$_2$CH$_3$  
   E. CH$_3$CH$_2$C(CH$_3$)$_3$

3. Cyclic alkanes differ from normal alkanes
   A. in the orbital hybridization on the carbon atoms.  
   B. in their utility as a combustible fuel.  
   C. in their color.  
   D. in the ratio of hydrogen to carbon.  
   E. all the above.

4. What is the systematic name for the aromatic compound shown below?
   
   ![Aromatic Compound]

   A. 1,1-diethylbenzene  
   B. 1-methyl-2-ethylbenzene  
   C. 3-phenylhexene  
   D. 1,2-dimethylbenzene  
   E. 1,2-diethylbenzene

5. The chemical reason why most animals do not eat cellulose is that
   A. cellulose contains $\alpha$-glycosidic bonds, which have a geometry that is easily hydrolysed by their digestive enzymes.  
   B. cellulose and starch are both glucose polymers and are a good food source for most animals.  
   C. cellulose contains $\beta$-glycosidic bonds, which have a geometry that cannot be hydrolysed by their digestive enzymes.  
   D. cellulose is a polymer like plastics that contain no nutrition.  
   E. cellulose is a polymer of fructose which most animals cannot use as an energy source.
6. Which of the functional groups listed below is **NOT** found in the molecule depicted?

![Molecule Image]

A. Amine  
B. Carboxylic Acid  
C. Alkene  
D. Alkyne  
E. Alcohol

7. The alcohol functional group has the bonding arrangement

A. C-O-C.  
B. C-O-H.  
C. C-NH₂  
D. Al-O-H.  
E. C-O-O-H.

8. Which of the following is **NOT** a difference between the structures of cyclohexane and benzene?

A. Cyclohexane can exist in both a chair and boat shape but benzene is planar.  
B. Cyclohexane carbons are sp³ hybridized but benzene carbons are sp² hybridized.  
C. Cyclohexane is puckered but benzene is planar.  
D. Cyclohexane has twelve hydrogen atoms in its structure but benzene has six hydrogen atoms in its structure.  
E. Cyclohexane is a combustible hydrocarbon but benzene has such a stable aromatic structure that it does not burn.

9. What is the systematic name of the following molecule?

![Molecule Image]

A. 5,6-dimethyl-6-ethyloctane  
B. 3-ethyl-3,4-dimethyloctane  
C. 2,2-diethyl-3-methylheptane  
D. 2-butyl-3-ethyl-3-methylpentane  
E. 6,6-diethyl-5-methylheptane
10. What is the systematic name of the following molecule?

![Molecule Image]

A. 4-isopropylheptane  
B. isoundecane  
C. 4-propyl-5-methylheptane  
D. 2-methyl-3-propylhexane  
E. 3-n-propyl-2-methylhexane

11. Which type of organic compound does NOT contain a carbonyl group?

A. linear sugars  
B. ethers  
C. aldehydes  
D. carboxylic acids  
E. ketones

12. Ethyl methyl ether is

A. CH₃OCH₃  
B. CH₃CH₂OCH₃  
C. (CH₃)₂CHCH₂OCH₃  
D. CH₃CH₂OCH₂CH₃  
E. CH₃CH₂CH₂OCH₃

13. An alkane with 9 carbons is called a

A. heptane  
B. nonadecane  
C. decane  
D. nonane  
E. ninane

14. Does this molecule have both cis and trans isomers?

![Molecule Image]

A. No, it has only the cis isomer.  
B. Yes, this is the cis isomer.  
C. No, it has only the trans isomer  
D. No.  
E. Yes, this is the trans isomer.
15. The figure below shows three possible paths for divers to ascend to the top of a 25 m diving board. Which path produces the largest change in potential energy?

A. depends on diver's muscle efficiency  
B. elevator  
C. They are all the same.  
D. ladder  
E. rope

16. How many degrees of temperature rise will occur when a 25.0 g block of aluminum absorbs 10.0 kJ of heat? The specific heat of Al is 0.900 J/g·°C.

A. 444°C  
B. 225°C  
C. 0.44°C  
D. 360°C  
E. 22.5°C

17. The energy stored in gasoline is a form of

A. work.  
B. heat.  
C. kinetic energy.  
D. potential energy.  
E. electromagnetic energy.

18. What is the change in internal energy (ΔE) when a system is heated with 35 J of heat while it does 15 J of work?

A. 50 J  
B. -20 J  
C. 20 J  
D. -50 J  
E. 5.3 x 10^2 J

19. Calculate the amount of work done, in joules, when 2.50 mole of H_2O vaporizes at 1.00 atm and 25°C. Assume the volume of liquid H_2O is negligible compared to that of vapor. [1 L·atm = 101.3 J]

A. 61.1 J  
B. 6,190 kJ  
C. 518 J  
D. 6.19 kJ  
E. 5.66 kJ
20. An exothermic reaction causes the surroundings to
   A. decrease its temperature.  B. warm up.
   C. expand.  D. become acidic.
   E. release CO$_2$.

21. A 0.1326 g sample of magnesium was burned in an oxygen bomb calorimeter. The total heat
capacity of the calorimeter plus water was 5,760 J/°C. If the temperature rise of the
calorimeter with water was 0.570°C, calculate the enthalpy of combustion of magnesium in
kJ/mol of Mg.

   \[ \text{Mg(s)} + \frac{1}{2}\text{O}_2(g) \rightarrow \text{MgO(s)} \]

   A. -602 kJ/mol  B. -3280 kJ/mol  C. 435 kJ/mol
   D. -24.8 kJ/mol  E. 106 kJ/mol

22. For the reaction \( \text{C(graphite)} + \text{O}_2(g) \rightarrow \text{CO}_2(g) \), \( \Delta H^\circ = -393 \text{ kJ/mol} \).
   How many grams of C(graphite) must be burned to release 275 kJ of heat?
   A. 8.40 g  B. 0.70 g  C. 17.1 g
   D. 22.3 g  E. 12.0 g

23. Ethanol (CH$_3$CH$_2$OH) has been suggested as an alternative fuel source. Ethanol's enthalpy
of combustion is \( \Delta H_c = -1368 \text{ kJ/mol} \). If the density of ethanol is 0.789 g/mL, how much
heat is released by burning 2.50 L of ethanol?
   A. 9.369 J  B. 31.96 kJ  C. 50.0 kJ
   D. 31.96 J  E. 5.856 \times 10^4 \text{ kJ}

24. The combustion of butane produces heat according to the equation
   \( 2\text{C}_4\text{H}_10(g) + 13\text{O}_2(g) \rightarrow 8\text{CO}_2(g) + 10\text{H}_2\text{O(l)} \)  \( \Delta H^\circ_{\text{rxn}} = -5,314 \text{ kJ} \).
   How many grams of CO$_2$ are produced per 1.00 X 10$^4$ kJ of heat released?
   A. 187 g  B. 23.4 g  C. 662 g
   D. 44.0 g  E. 82.3 g

25. Estimate the enthalpy change for the reaction \( 2\text{CO} + \text{O}_2 \rightarrow 2\text{CO}_2 \) given the following bond
energies.

   \[ \text{BE(C=O)} = 1074 \text{ kJ/mol} \]
   \[ \text{BE(O=O)} = 499 \text{ kJ/mol} \]
   \[ \text{BE(C=O)} = 802 \text{ kJ/mol} \]

   A. +1949 kJ  B. +744 kJ  C. -744 kJ
   D. -561 kJ  E. +2380 kJ

26. Given \( \text{H}_2(g) + (1/2)\text{O}_2(g) \rightarrow \text{H}_2\text{O(l)} \), \( \Delta H = -286 \text{ kJ/mol} \), determine the enthalpy change for
the reaction \( 2\text{H}_2\text{O(l)} \rightarrow 2\text{H}_2(g) + \text{O}_2(g) \).

   A. +572 kJ  B. +286 kJ  C. -286 kJ
   D. -572 kJ  E. -143 kJ
27. Given the thermochemical equation \(2\text{SO}_2(g) + \text{O}_2(g) \rightarrow 2\text{SO}_3(g), \Delta H^\circ_{\text{rxn}} = -198 \text{ kJ/mol},\) how much heat is evolved when 600. g of \(\text{SO}_2\) is burned?

A. 59,400 kJ  
B. 5.46 \times 10^{-2} \text{ kJ}  
C. 928 kJ  
D. 3.71 \times 10^3 \text{ kJ}  
E. 1.85 \times 10^3 \text{ kJ}

28. Which of the following compounds is less stable than its elements under standard conditions?

A. \(\text{PH}_3\) (g), \(\Delta H^\circ_{\text{f}} = 5.4 \text{ kJ/mol}\)  
B. \(\text{KCl}\) (s), \(\Delta H^\circ_{\text{f}} = -435.9 \text{ kJ/mol}\)  
C. \(\text{Fe}_3\text{O}_4\) (s), \(\Delta H^\circ_{\text{f}} = -1117.1 \text{ kJ/mol}\)  
D. \(\text{CO}_2\) (g), \(\Delta H^\circ_{\text{f}} = -393.5 \text{ kJ/mol}\)  
E. \(\text{NiO}\) (s), \(\Delta H^\circ_{\text{f}} = -239.7 \text{ kJ/mol}\)

29. To which one of the following reactions occurring at 25°C does the symbol \(\Delta H^\circ_{\text{f}}[\text{H}_2\text{SO}_4(l)]\) refer?

A. \(2\text{H(g)} + \text{S(g)} + 4\text{O(g)} \rightarrow \text{H}_2\text{SO}_4(l)\)  
B. \(\text{H}_2(g) + \text{S(s)} + 2\text{O}_2(g) \rightarrow \text{H}_2\text{SO}_4(l)\)  
C. \(\text{H}_2\text{SO}_4(l) \rightarrow 2\text{H(g)} + \text{S(s)} + 4\text{O(g)}\)  
D. \(\text{H}_2(g) + \text{S(g)} + 2\text{O}_2(g) \rightarrow \text{H}_2\text{SO}_4(l)\)  
E. \(\text{H}_2\text{SO}_4(l) \rightarrow \text{H}_2(g) + \text{S(s)} + 2\text{O}_2(g)\)

30. Given the enthalpies of formation for the following substances, determine \(\Delta H_{\text{rxn}}\) for

\[
\text{Cl}_2(g) + \text{C}_2\text{H}_2\text{Cl}_2(g) \rightarrow \text{C}_2\text{H}_2\text{Cl}_4(g).
\]

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A. 159.9 kJ/mol  
B. -151.3 kJ/mol  
C. -159.9 kJ/mol  
D. 151.3 kJ/mol  
E. -155.6 kJ/mol

31. Which of the following is an element in its standard state at 25°C and 1 atm?

A. \(\text{N}\) (g)  
B. \(\text{O}_2\) (g)  
C. \(\text{H}\) (g)  
D. \(\text{C}\) (s, diamond)  
E. \(\text{NaCl}\) (s)
32. Calculate the standard enthalpy change for the reaction
\[ 2\text{C}_8\text{H}_{18}(l) + 21\text{O}_2(g) \rightarrow 8\text{CO}(g) + 8\text{CO}_2(g) + 18\text{H}_2\text{O}(l). \]

Given:
\[ 2\text{C}_8\text{H}_{18}(l) + 25\text{O}_2(g) \rightarrow 16\text{CO}_2(g) + 18\text{H}_2\text{O}(l) \quad \Delta H^\circ = -11,020 \text{ kJ/mol} \]
\[ 2\text{CO}(g) + \text{O}_2(g) \rightarrow 2\text{CO}_2(g) \quad \Delta H^\circ = -566.0 \text{ kJ/mol} \]

A. -8,756 kJ  B. 1.1586 \times 10^4 \text{ kJ}  C. -6,492 kJ
D. -1.0454 \times 10^4 \text{ kJ}  E. 1.0454 \times 10^4 \text{ kJ}

33. As plant tissue is converted to coal by heat and pressure deep underground H and O are lost from the material. Thus younger coal usually

A. is lower in energy content.
B. is higher in energy content.
C. contains fewer aromatic rings.
D. is softer.
E. is diamond like.

34. Professor Popsnorkle has invented a catalyst that promotes rearrangement of alkanes. Depending on the conditions used it can promote either the conversion of normal alkanes to their branched isomers, or conversion of branched alkanes to their normal alkane isomers. Which reaction would make Professor Popsnorkles invention worth more to an oil company?

A. Both would be equally valuable.
B. The conversion of branched chain alkanes to normal isomers is more valuable.
C. The catalyst would be worthless to an oil company.
D. The conversion of normal alkanes to branched chain isomers is more valuable.

35. Coal is produced by exposure of plant tissue to high pressures and temperatures in a low oxygen environment. This

A. forces the loss of much of the H and O in the sample resulting in a material that is primarily graphite.
B. converts the material to diamonds.
C. reduces the material to a black solid.
D. prevents the decay of the plant matter resulting in a good fuel.
E. forces the loss of much of the H and O in the sample resulting in a material that is very dry.

36. Distillation is most effective in separating volatile mixtures when

A. the component liquids have big differences in vapor pressures.
B. the solution is ideal.
C. the distillation is carried out in many repeated steps.
D. all the above
37. Biomass fuels like methane and ethanol are produced by biological decay processes. In the case of ethanol the process is anerobic fermentation of sugar to produce the ethanol. Methane is produced by the bacterial action on a number of compounds including carboxylic acids and amines. Some example reactions are shown below with their enthalpy changes.

\[ C_6H_{12}O_6(s) \rightarrow 2 C_2H_6O(l) + 2 CO_2(g) \quad \Delta H = -67 \text{ kJ} \]

\[ 2(CH_3)_2NH(l) + 2H_2O(l) \rightarrow 3CH_4(g) + CO_2(g) + 2NH_3(aq) \quad \Delta H = -119.1 \text{ kJ} \]

What can we conclude about the energy content of the biomass fuel compared to the energy content of the starting materials?

A. The biomass fuel is higher energy content than the starting material.
B. The biomass fuel has no energy content.
C. The biomass fuel is lower energy content than the starting material.
D. There is an arbitrary relationship between the energy content of the biomass fuel and the starting material.
E. The biomass fuel has the same energy content as the starting material.

38. Glucose and fructose undergo a _______ reaction in the formation of sucrose.

A. hydrolysis    B. sugarization    C. sweetening    D. precipitation    E. condensation

39. The following cartoon represents which form of the glucose molecule?

A. \( \delta \)  B. \( \gamma \)  C. \( \alpha \)  D. \( \epsilon \)  E. \( \beta \)
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