If you do not want your graded exam placed in the box outside my office, then please tick here

Answer all the questions.

1) Draw Lewis structures (lines for bonds and dots for all lone pairs) for the following molecules: (8pts)
   
   (a) BF$_3$

   (b) BrCH$_2$CH$_2$CH$_2$OH

   (c)

   (d)

2) What is the hybridization of the: (6pts)
   
   (i) Boron in (1a)

   (ii) Carbon attached to bromine in (1b)

   (iii) The $\pi$ bonded oxygen in (1c)

   (iv) The tertiary carbon in (1d)
3) Explain in a simple sentence what is meant in a chemical sense by the following arrows. (10pts)

(a) 

(b) 

(c) 

(d) 

(e) 

4) (i) Write all the resonance forms for the following two species. (ii) Indicate which are major and minor contributors (or if they are the same energy). (ii) Use curly arrows to show the movement of electrons which converts one into the others. (12pts)

(a) 

(b) 

CH₃-C-C≡N

H
5) (i) Indicate which reactant is acting as a BASE and which is acting as an ACID for the following reactions.
(ii) Also circle the conjugate acid of the basic species. (6pts)

(a) HCl + H₂O → H₃O⁺ + Cl⁻

(b) CH₃CH₂O⁻ + CH₃·Br → CH₃CH₂OCH₃ + Br⁻

6) How are entropy, Gibbs free energy and enthalpy mathematically related? (3pts)

7) On the below energy level diagram, label (a) the axes (b) the reactants and products (c) any transitions states (d) ΔH° for the overall reaction (e) the rate determining step, and (f) is this reaction exothermic or endothermic? (10pts)
8) Explain why CH$_3^+$ (methyl cation) has a different three dimensional geometry to CH$_3^-$ (methyl anion).
(Hint: one is trigonal planar and the other is tetrahedral). (10pts)

9) Which of the above species is a better electrophile? (2pts)
10) Name the following compounds in IUPAC form: (15pts)

(a) 

(b) 

(c) 

(d) 

(e)
11) Even in its most stable geometry, Bromo-cyclohexane can exist as two conformers.
(i) Draw these two conformers
(ii) label which is the more stable, and
(iii) in a sentence explain why one is more stable. (10pts)
12) (i) Rank the following radicals in increasing stability.

(a) \[ \text{structure} \]

(b) \[ \text{structure} \]

(c) \[ \text{structure} \]

(ii) identify each as either primary, secondary or tertiary. (8pts)
Name: S. M. Artarse

If you do not want your graded exam placed in the box outside my office, then please tick here _______

Answer all the questions.

1) Draw Lewis structures (lines for bonds and dots for all lone pairs) for the following molecules:

(a) BF₃

(b) BrCH₂CH₂CH₂OH

(c)

(d)

2) What is the hybridization of the:
   (i) Boron in (1a)
   (ii) Carbon attached to bromine in (1b)
   (iii) The π bonded oxygen in (1c)
   (iv) The tertiary carbon in (1d)
3) Explain in a simple sentence what is meant in a chemical sense by the following arrows.

(a) \[ \text{reacts to give} \]

(b) \[ \text{movement of two electrons} \]

(c) \[ \text{movement of one electron} \]

(d) \[ \text{is in equilibrium with} \]

(e) \[ \text{is a resonance form of} \]

4) (i) Write all the resonance forms for the following two species.
(ii) Indicate which are major and minor contributors (or if they are the same energy).
(iii) Use curly arrows to show the movement of electrons which converts one into the others.

(a) \[ \begin{array}{c}
\text{SAME}\quad \text{ENERGY}\quad \text{(same molecule)}
\end{array} \]

(b) \[ \begin{array}{c}
\text{MINOR} \\
\text{MAJOR (N more E.N. than C)}
\end{array} \]
5) (i) Indicate which reactant is acting as a BASE and which is acting as an ACID for the following reactions. (ii) Also circle the conjugate acid of the basic species.

(a) \( \text{HCl} + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{Cl}^- \)

(b) \( \text{CH}_3\text{CH}_2\text{O}^- + \text{CH}_3\text{Br} \rightarrow \text{CH}_3\text{CH}_2\text{OCH}_3 + \text{Br}^- \)

6) How are entropy, Gibbs free energy and enthalpy mathematically related?

\[ \Delta G = \Delta H - T \Delta S \]

7) On the below energy level diagram, label (a) the axes (b) the reactants and products (c) any transitions states (d) \( \Delta H^0 \) for the overall reaction (e) the rate determining step, and (f) is this reaction exothermic or endothermic?
8) Explain why $\text{CH}_3^+$ (methyl cation) has a **different** three dimensional geometry to $\text{CH}_3^-$ (methyl anion).
(Hint: one is trigonal planar and the other is tetrahedral).

$\text{CH}_3^+$ has 3 $\sigma$ bonds
0 lone pairs $\Rightarrow sp^2$ hybridization

empty, unhybridized p orbital

$sp^2$ = trigonal planar geometry
120° bond angles.

$\text{CH}_3^-$ has 3 $\sigma$ bonds
1 lone pair $\Rightarrow sp^3$ hybridization

all $sp^3$ orbitals, bond angle ~109° 

tetrahedral shape.

9) Which of the above species is a better **electrophile**?

$\text{CH}_3^+$ is the better electrophile
10) Name the following compounds in IUPAC form:

(a) \( \text{pentane} \)

(b) \( \text{2-methylheptane} \)

(c) \( \text{2,2,3-trimethylbutane} \)

(d) \( \text{2-methylbutane} \)

(e) \( \text{cis-1,2-dimethylcyclobutane} \)
11) Even in its most stable geometry, Bromo-cyclohexane can exist as two conformers.
(i) Draw these two conformers
(ii) label which is the more stable, and
(iii) in a sentence explain why one is more stable.

2 chair forms of bromocyclohexane,

(i) Br axial

(ii) Br equatorial

MORE STABLE
since the equatorial bromine points away from the rest of the molecule which reduces steric hindrance by reducing e⁻/e⁻ repulsions
(i) Rank the following radicals in increasing stability.

(a) \text{ PRIMARY}

(b) \text{ TERTIARY}

(c) \text{ SECONDARY}

(ii) Identify each as either primary, secondary or tertiary. (8pts)