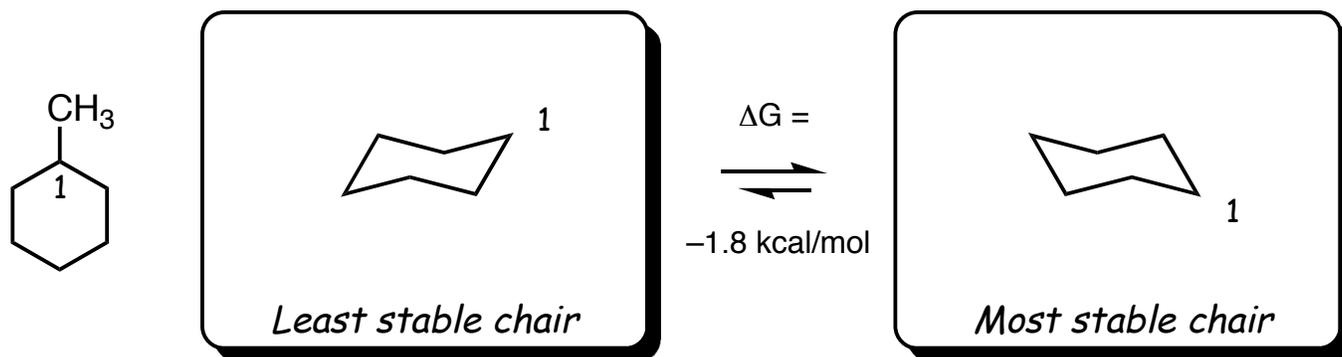**Q1.** (a) Methylcyclohexane can exist in two different chair conformations, one of which is 1.8 kcal/mol more stable than the other, i.e., the **A value** for the methyl group is 1.8. In each of the two boxes below, draw in a bond to one methyl (**CH₃**) group in the appropriate position. (2 pt)

CH₃

1

ΔG =

−1.8 kcal/mol

Least stable chair

1

Most stable chair

(b) Chlorocyclohexane also exists in two different chair conformations, one of which is 0.6 kcal/mol more stable than the other, i.e., the **A value** for the chloro group is 0.6. In each of the two boxes below, draw in a bond to one chloro (**Cl**) group in the appropriate position. (2 pt)
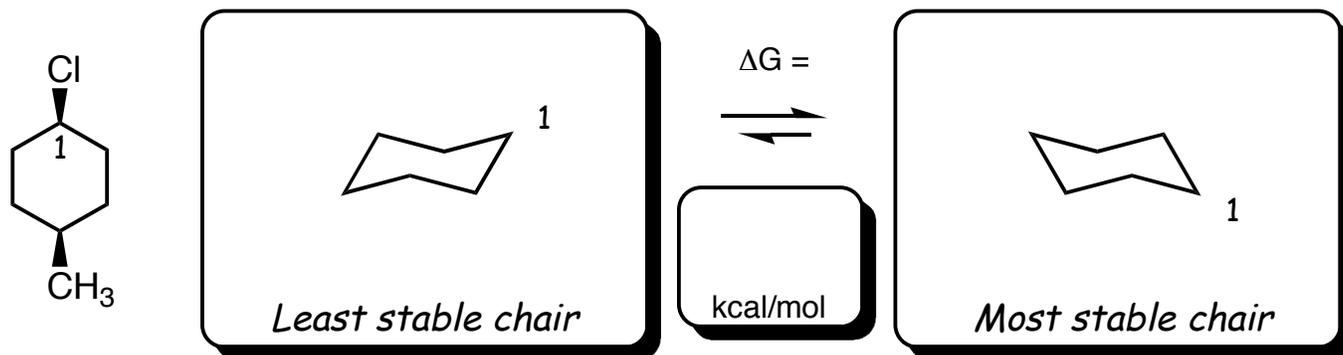
Cl

1

ΔG =

−0.6 kcal/mol

Least stable chair

1
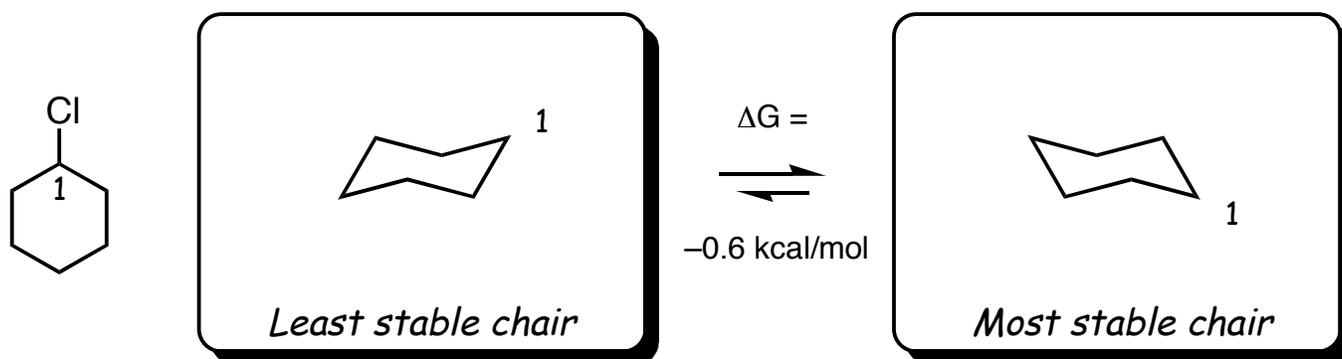
Most stable chair

(c) For *trans*-1-chloro-4-methylcyclohexane (shown below), draw in bonds to **CH₃** and **Cl** groups as appropriate, to indicate the least and most stable chair conformers. Assuming that **A values** are additive (and hence subtractive if necessary...), predict what the ΔG value will be. (6 pt)

Cl

1

CH₃

1

ΔG =

kcal/mol

Least stable chair

1
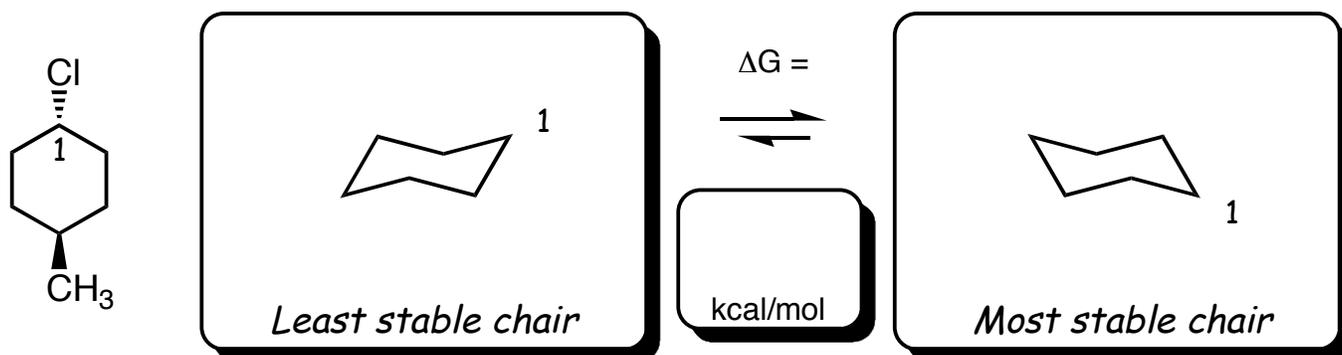
Most stable chair

(d) For *cis*-1-chloro-4-methylcyclohexane (shown below), draw in bonds to **CH₃** and **Cl** groups as appropriate, to indicate the least and most stable chair conformers. Assuming that **A values** are additive (and hence subtractive if necessary...), predict what the ΔG value will be. (6 pt)
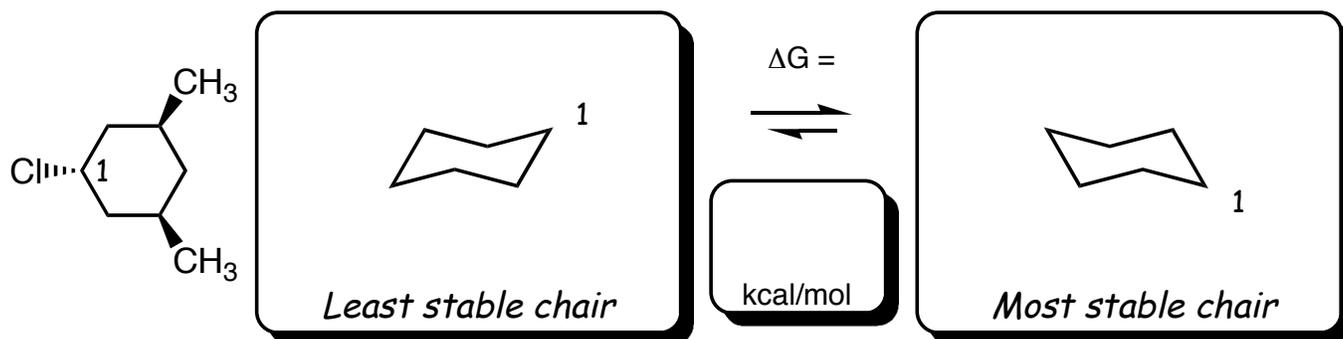
$\Delta G =$

Least stable chair

kcal/mol

Most stable chair

(e) For the isomer of 1-chloro-3,5-dimethylcyclohexane shown below, draw in bonds to **CH₃** and **Cl** groups as appropriate, to indicate the least and most stable chair conformers. Assuming that **A values** are additive (and hence subtractive if necessary...), predict what the ΔG value will be. (8 pt)

$\Delta G =$

Least stable chair
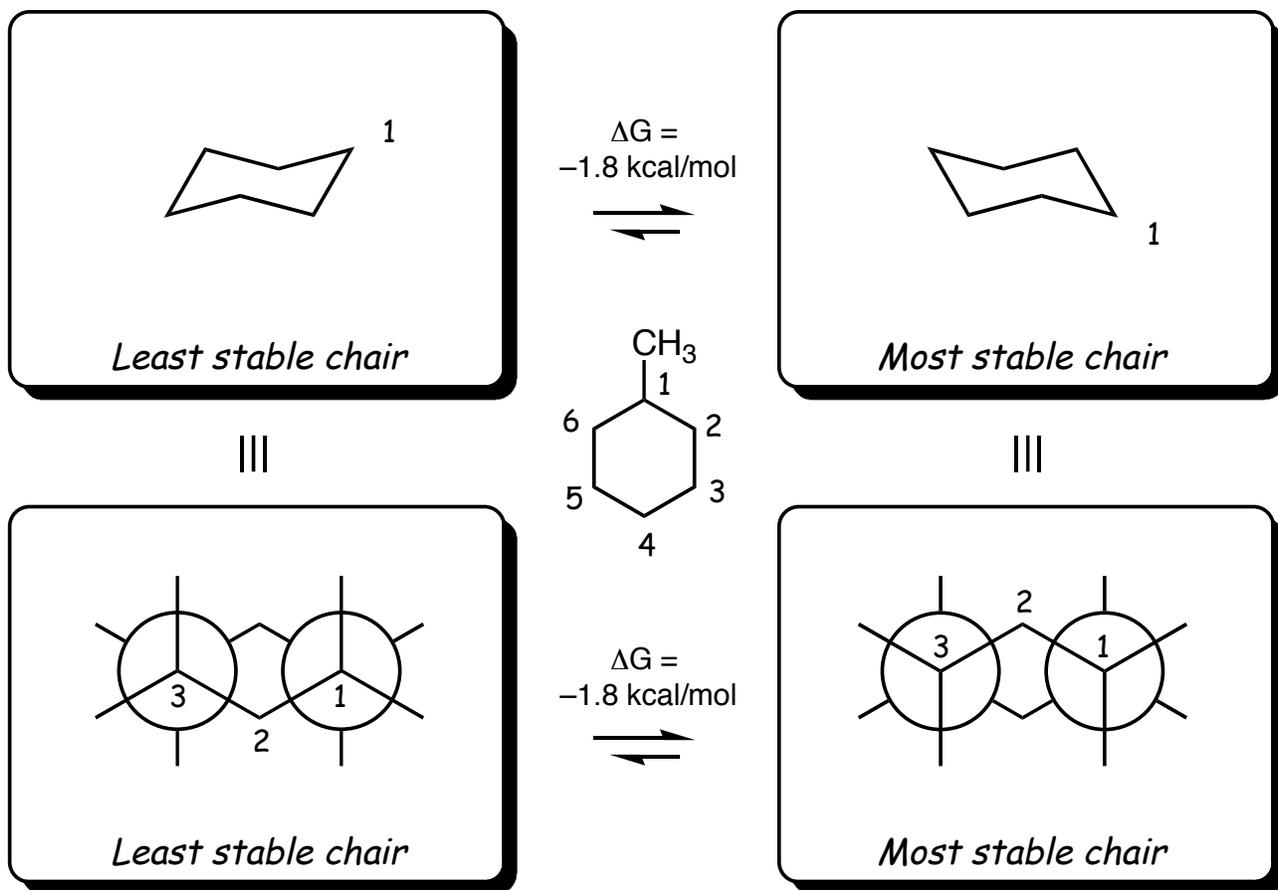
kcal/mol

Most stable chair

(f) In the appropriate boxes below, draw the three most stable conformations of cyclohexylcyclohexane (shown to the right) in which the indicated H atoms maintain an **ANTI** relationship, i.e., are 180° apart. Once you have drawn these three **different** conformers, use the box below them to briefly explain your answers. (12 pt)

Cyclohexylcyclohexane

Cyclohexylcyclohexane

Most Stable Conformer

2nd Most Stable Conformer

3rd Most Stable Conformer
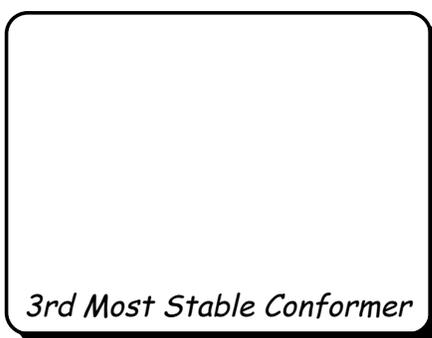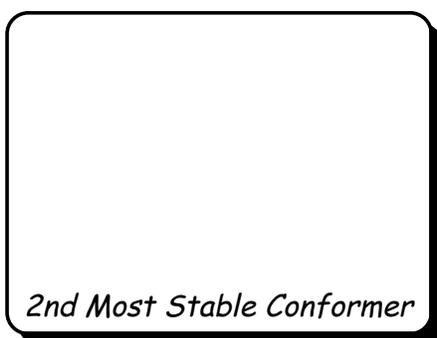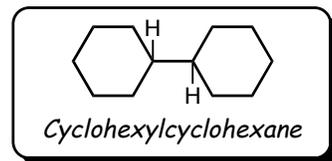
Explanation:

Q2. **(a)** Methylcyclohexane (shown in the middle below) can exist in two different chair conformations, one of which is 1.8 kcal/mol more stable than the other. In each of the top two boxes below, draw in a bond to one methyl (Me) group in the appropriate position. In the bottom two boxes, complete the Newman projections by filling in methyl (Me) groups AND hydrogen atoms (H) where appropriate. (4 points)


ΔG = −1.8 kcal/mol

Least stable chair   Most stable chair

III   III

ΔG = −1.8 kcal/mol

Least stable chair   Most stable chair

(b) *trans*-1,4-Dimethylcyclohexane (shown below) also exists in two different chair conformations, one of which is **3.6 kcal/mol** more stable than the other. In each of the boxes below, draw in methyl (Me) groups in the appropriate positions. (4 points)

ΔG = −3.6 kcal/mol

Least stable chair   Most stable chair
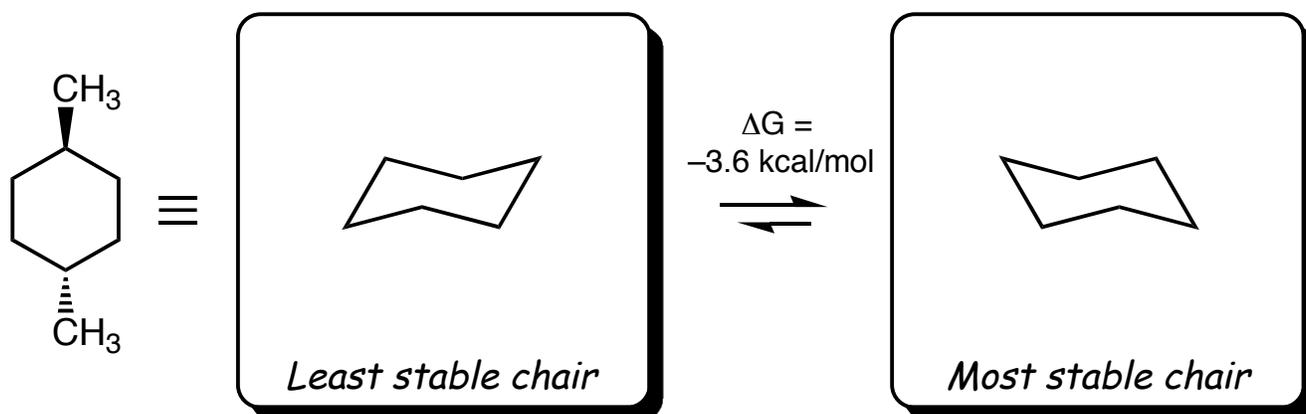
Question 3 is continued on the next page...

(c) *trans*-1,2-Dimethylcyclohexane (shown below) also exists in two different chair conformations, one of which is **2.7 kcal/mol** more stable than the other. In each of the boxes below, draw in methyl (Me) groups in the appropriate positions. (4 points)
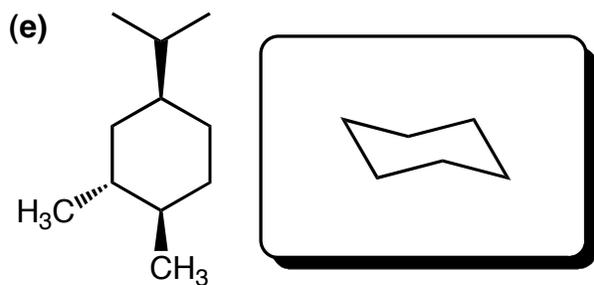

Least stable chair

$$\Delta G = -2.7 \text{ kcal/mol}$$

Most stable chair
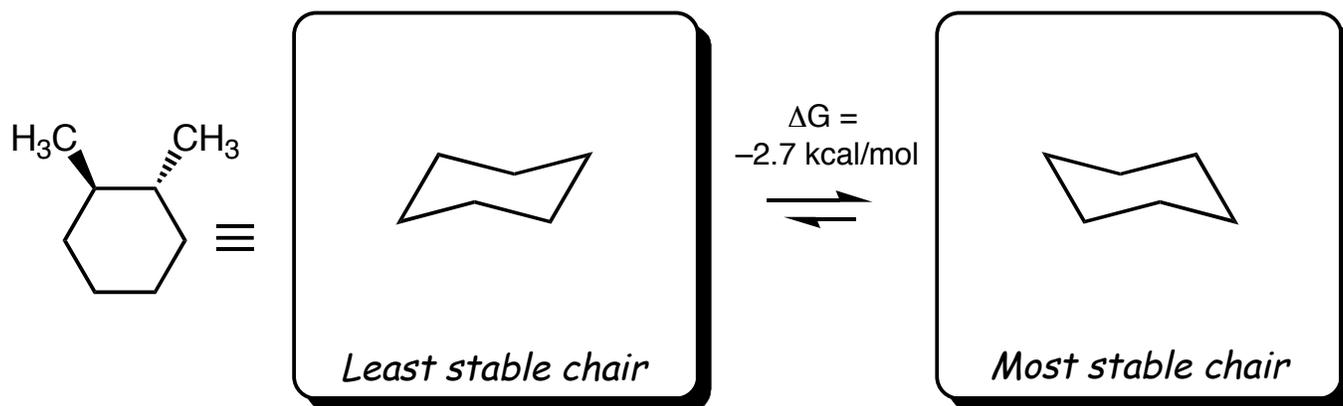
(d) In the box below, explain (using appropriate diagrams if you wish), why the difference in energy between the two chair conformations of *trans*-1,2-dimethylcyclohexane is **0.9 kcal/mol** LESS than the difference in energy between the two chair conformations of *trans*-1,4-dimethylcyclohexane. (8 points)
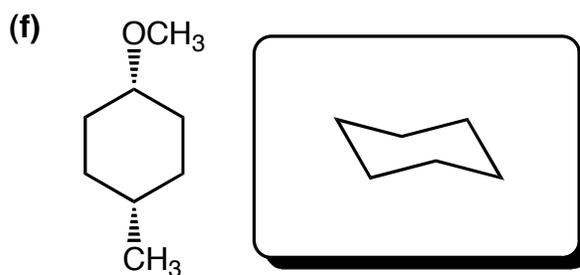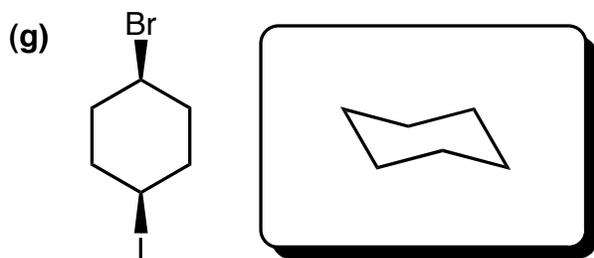
For each of the questions below (**e–h**) draw the most stable chair conformation for each compound, and in each case give a succinct reason for your choice. (*Hint: the answers aren't perhaps as easy as you may think they are...*) (2 + 2 points each)
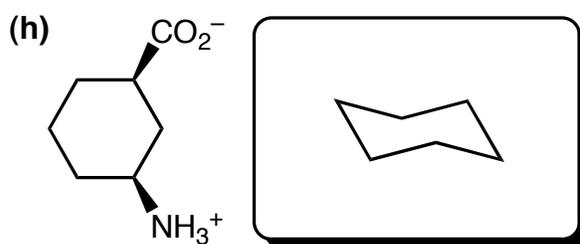
(e)

reason:

(f) OCH₃ / CH₃

reason:

(g) Br

reason:

(h) CO₂⁻ / NH₃⁺

reason:

(**i**) When the compound in part (**h**) is treated with a strong acid, a new compound is formed. Draw the most stable chair conformation of this new product and justify your choice (4 points)