

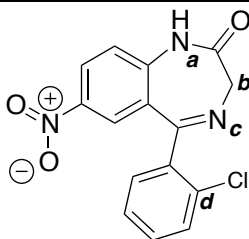
Poll question: How much time did you spend studying for this exam over the past week? Round to the nearest hour and enter the number in the "EXAM NUMBER" section of the Scantron form. Example: 7 hours studying, enter "007" or 14 hours studying, enter "014"

Section 1: Multiple choice. Questions 1-35 must be answered on the Scantron form by shading the appropriate circle with blue or black pen or pencil. Scantron responses will be used to calculate your grade. Please indicate your answers on this examination paper in the event your Scantron is lost.

Note that **more than one letter** could be entered as an answer to a multiple choice question. Questions are not equally weighted in marks; it is **not 1 mark per answer**.

questions 1 to 5:

Consider the molecule (*clonazepam, an anticonvulsant pharmaceutical*) to the right. Take note of the fact that specific atoms in this structure have been labelled **a** through **d**.



1) Indicate the hybridization of the nitrogen atom labelled **a**:

(a) s (b) p (c) sp (d) sp² (e) sp³ (f) σ (sigma) (g) π (pi)

2) Indicate the hybridization of the carbon atom labelled **b**:

(a) s (b) p (c) sp (d) sp² (e) sp³ (f) σ (sigma) (g) π (pi)

3) Indicate the hybridization of the nitrogen atom labelled **c**:

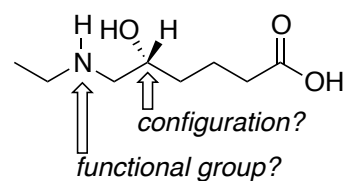
(a) s (b) p (c) sp (d) sp² (e) sp³ (f) σ (sigma) (g) π (pi)

4) Indicate the hybridization of the carbon atom labelled **d**:

(a) s (b) p (c) sp (d) sp² (e) sp³ (f) σ (sigma) (g) π (pi)

5) The functional group that incorporates the nitrogen atom labelled **c** is an example of an:

(a) amine (b) imine (c) emine (d) amide (e) amidine (f) ammonium (g) none of these



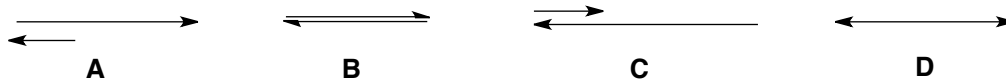
6) The configuration of the stereogenic carbon atom is:

- (a) Z configuration
- (b) E configuration
- (c) R configuration
- (d) S configuration
- (e) L configuration
- (f) D configuration

7) The indicated functional group is:

- (a) 1° amide
- (b) 2° amide
- (c) 3° amide
- (d) 1° amine
- (e) 2° amine
- (f) 3° amine
- (g) 1° imine
- (h) 2° imine

• For questions 8)-14), select the letter (A, B, C, D) that corresponds to the arrows that best describes the relationship between the 'reactants' and 'products'. Be sure to fill in your Scantron!

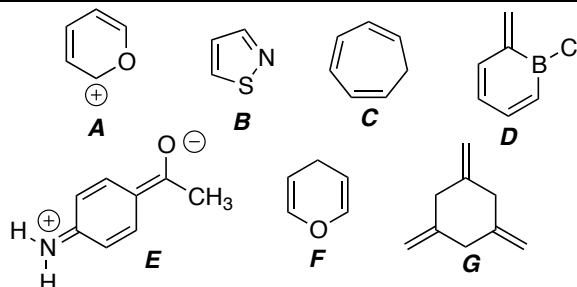


- 8)
- 9)
- 10)
- 11)
- 12)
- 13)
- 14)

question 15:

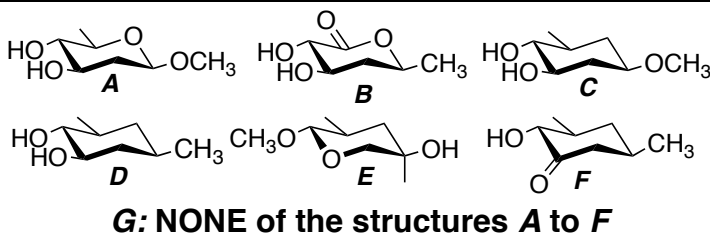
Consider the series **A-G** on the right.

Indicate the species that have *aromatic character*. Note that incorrect selections will be subtracted from correct.



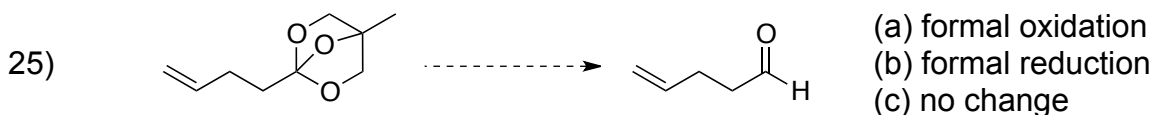
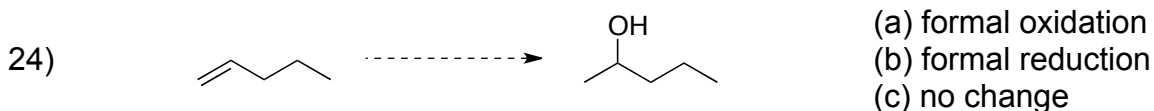
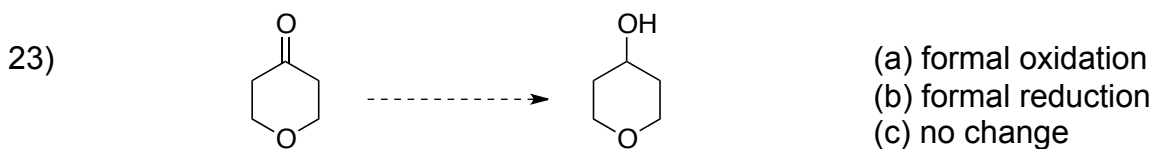
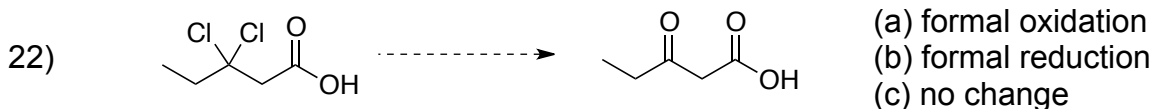
questions 16 to 21:

Consider the series **A-G** on the right. For each question, select ALL compounds that apply. Take note that *incorrect selections will be subtracted from correct selections.*

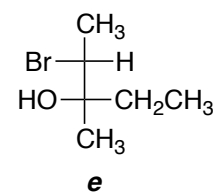
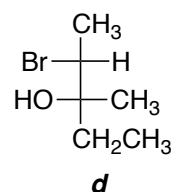
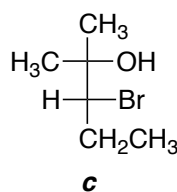
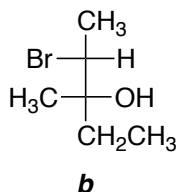
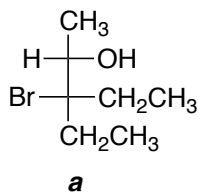
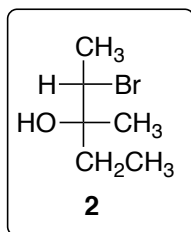


- 16) Select compound(s) that contain an ether functional group.
- 17) Select compound(s) that contain a carbonyl functional group.
- 18) Select compound(s) that contain a primary (1°) alcohol.
- 19) Select compound(s) that contain a tertiary (3°) alcohol.
- 20) Select compound(s) that contain a functional group at the same oxidation level as a carboxylic acid.
- 21) Select compound(s) that contain an acetal functional group.

• For questions 22-25, indicate whether the hypothetical transformation is a *formal oxidation*, *formal reduction*, or *no change in oxidation level*:



• Questions 26-28: Consider the compounds **2**, and **a-e** (below) when answering. More than one letter *may* be indicated in your answers. Take note that incorrect answers will be subtracted from correct answers.



26) What compound(s) **a-e** is/are *enantiomer(s)* of compound **2**?

27) What compound(s) **a-e** is/are *constitutional isomer(s)* of compound **2**?

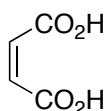
28) What compound(s) **a-e** is/are *diastereomer(s)* of compound **2**?

• Questions 29 to 35. Each of the following phrases is either:

(A) true

(B) false

(C) cannot be determined

29)  is a meso compound.

30) There is a greater concentration of a major resonance structure in solution compared to the concentration of a minor resonance structure.

31) 2-Octanone would be expected to be more soluble in hexane than in water.

32) The pH is a chemical property that reflects the ability to dissociate a proton from a functional group in a molecule.

33) Ethylammonium chloride would be expected to be more soluble in hexane than in water.

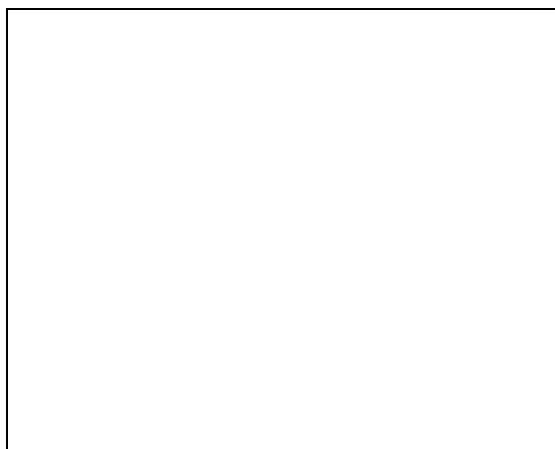
34) Cyclic compounds containing conjugated alkenes obey the Hückel rule.

35) A strand of deoxyribonucleic acid (DNA) would be expected to be more soluble in hexane than in water.

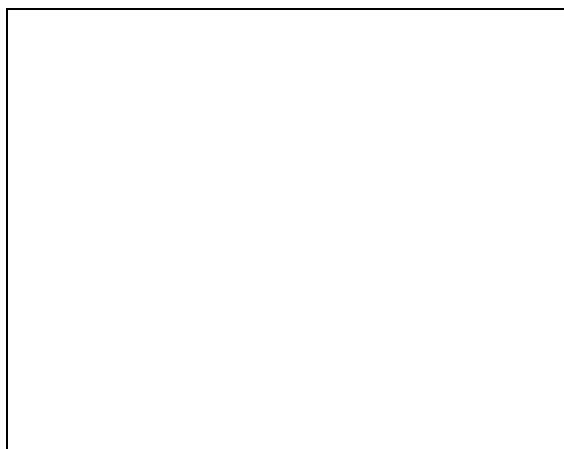
Section 2. Short answer questions. Please write your answers in the designated space. Please note that in some cases it is better for you to work out your answer on practice paper and copy a neat version to the examination paper.

****Messy and/or incoherent answers that are difficult to read or interpret may receive reduced or zero credit.****

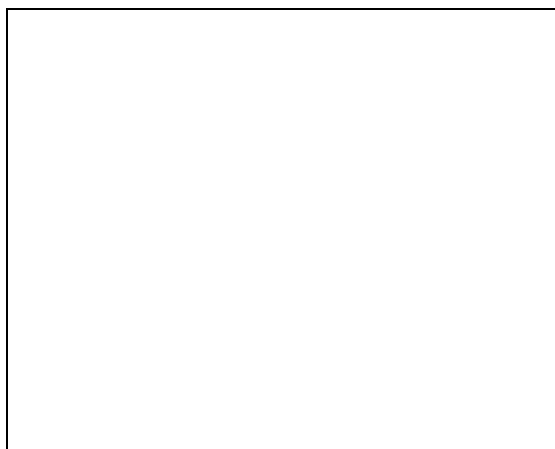
2-1) (8 marks) Draw formal Lewis structures with all lone pairs and formal charges clearly shown. If appropriate, provide only the most significant resonance contributor.



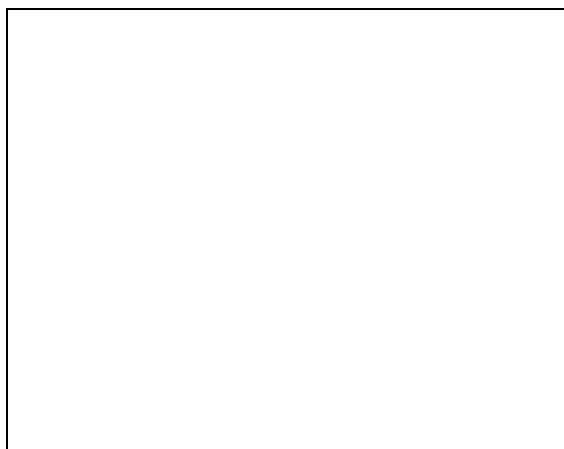
• conjugate acid of propanone
(C₃H₇O)



• conjugate base of propanone
(C₃H₅O)

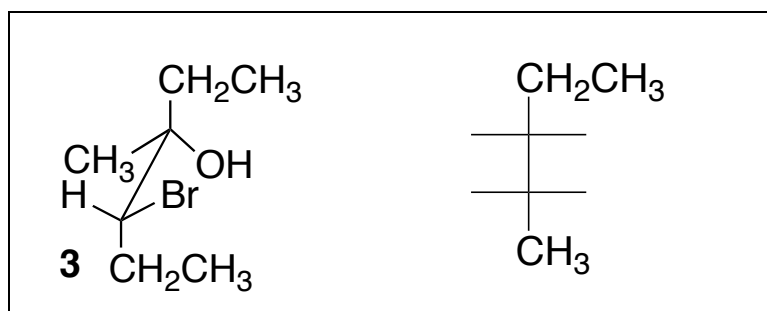


• (Z)-2-bromo-3-chloro-2-butene



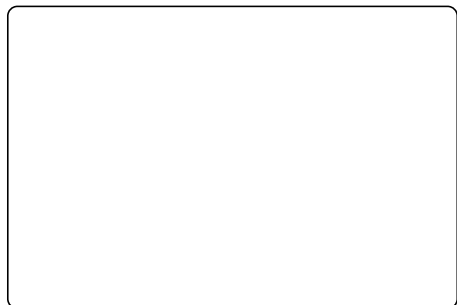
• methyl isocyanate, H₃CNCO

2-2) (2 marks) Using the supplied template, provide a *Fischer projection* for compound **3**:



2-3) (6 marks) The compound **3-butene-2-one** (methyl vinyl ketone) is an important industrial chemical. It reacts rapidly with Lewis basic nucleophiles.

- provide the structure of **3-butene-2-one** using a LINE-BOND structure in the box provided.
- provide two contributing resonance structures in the space provided to the right of the box. Be sure to *clearly indicate* lone pairs and non-zero formal charges on your structures as needed.
- indicate your prediction for reactive sites on **3-butene-2-one** upon reaction with a nucleophilic Lewis base such as sodium thioethoxide ($\text{Na-SCH}_2\text{CH}_3$) by **STARRING** (e.g. ★) specific positions on your picture in the box below.

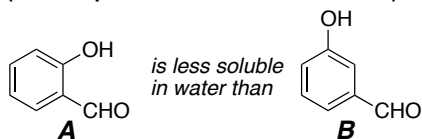


• structure of **3-butene-2-one**

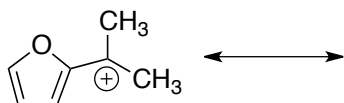
• contributing resonance structure(s)

2-4) (4 marks) Compound **A** is less soluble in water than compound **B**. Using drawings accompanied with *brief comments*, provide an explanation for this observation.

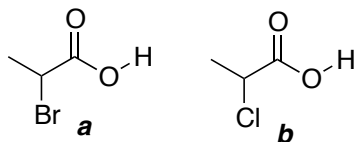
(note: pictures=1000 words)



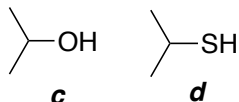
2-5) (6 marks) Draw the *major contributing resonance structures* for the following cation:



2-6) (4 marks) Circle the most acidic compound between compounds **a** and **b** below. Justify your selection with brief comments. Note that stating that one compound has a lower pK_A than the other will not receive credit!



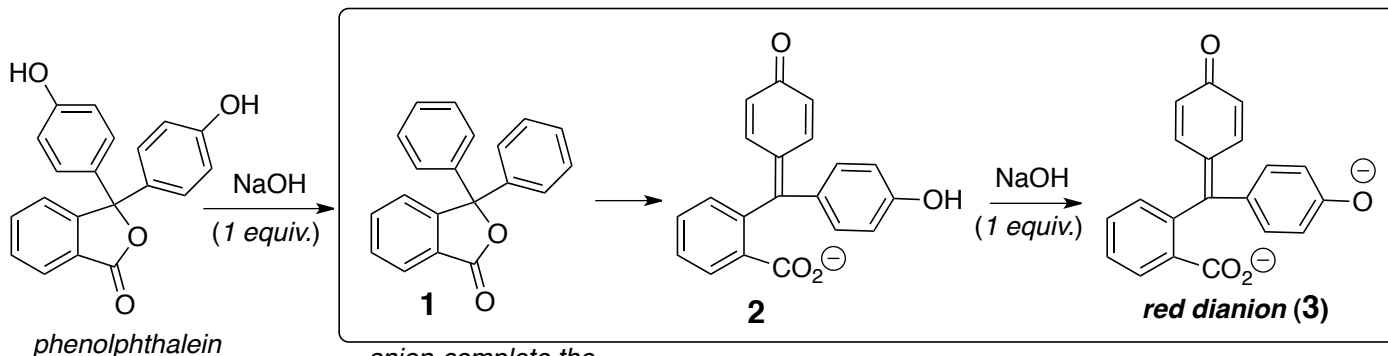
2-7) (4 marks) Circle the most acidic compound between compounds **c** and **d** below. Justify your selection with brief comments. Note that stating that one compound has a lower pK_A than the other will not receive credit!



2-8) (4 marks) Phenolphthalein is a common laboratory indicator that is colorless in acid, but reacts with two (2) equivalents of a base, like sodium hydroxide, to produce a red dianion (**3**, below).

a) complete the structure of the first intermediate **1**

b) on structure **1**, draw curved arrows to represent electron movement that would result in the formation of intermediate **2**.



anion-complete the structure **1** AND draw arrows to generate structure **2**