Option B: Drugs and Medicine: Exam Questions & Answers

Question 1. (a) Many drugs are taken orally. State three other ways in which drugs may be taken by a patient.
   (b) State what is meant by the term side effect.

Answer: 1. (a) rectally/by suppository, by inhalation, by injection (parenterally), by applying to skin/topically;
   (b) an effect produced as well as the one intended/unwanted or undesired effect;

Question 2. One common type of drug taken orally is the antacid. Antacids such as sodium hydrogen carbonate are taken to reduce stomach acidity.
   (i) State the names of two metals, other than sodium, whose compounds are often used in antacids.
   (ii) Give an equation for the neutralization of hydrochloric acid in the stomach by sodium hydrogen carbonate.
   (iii) Explain how heartburn is caused.
   (iv) Explain why dimethicone is added to some antacids.

Answer: 2. (i) magnesium/Mg, aluminium/Al, calcium/Ca;
   (ii) $\text{NaHCO}_3 + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O} + \text{CO}_2$ (not $\text{H}_2\text{CO}_3$);
   (iii) acid from the stomach rises into the esophagus;
   (iv) as an anti-foaming agent/to prevent problem in (iii)/to prevent flatulence;

Question 3. (i) State what is meant by the term analgesic. Explain the difference in the mode of action of mild and strong analgesics.
   (ii) State the general names of the two functional groups attached to the benzene ring in a molecule of aspirin.
   (iii) The use of aspirin can have beneficial effects for the user, but can also produce some unwanted side effects. State one beneficial effect (other than its analgesic action) and one unwanted side effect.

Answer: 3. (i) a substance that reduces pain;
mild analgesics intercept pain at the source/interfere with production of substances that cause pain;
strong analgesics bond to receptor sites in the brain/prevent the transmission of pain impulses;
(ii) carboxylic (acid)/alkanoic (acid); ester;
(iii) Any one of the following [1]. beneficial effects
   used to treat mini-strokes;
   prevents heart attacks/reduces risk of heart attack/thins the blood/anti-coagulant;
   relieves symptoms of rheumatological diseases/anti-inflammatory;
   reduces fever;
Any one of the following side effects
      stomach bleeding, allergic reaction; Reye’s syndrome; hearing loss;
      tinnitus (ringing in the ears); gastrointestinal irritation (e.g. heartburn, nausea);

Question: 4.  Morphine is a naturally occurring analgesic that can be converted into codeine.
   (i) Calculate the difference in relative formula mass between morphine and codeine.  1
   (ii) Explain what is meant by developing tolerance towards codeine and state why this is dangerous.
Answer: 4.  (i) 14/14.03 (ignore units);  1
   (ii) increasing amounts needed to produce same effect;
        increasing amounts cause damage/death;  2

Question: 5.  Discuss two arguments for and two arguments against the legalization of cannabis.
Answer: 5.  Arguments for:
      effective for certain named diseases;
      no more (or less) damaging than other drugs e.g. tobacco, alcohol;
      personal freedom argument/more taxes/frees police to deal with more serious crimes;

Arguments against:
      some harmful effects/specifed example, e.g. increased risk of lung cancer;
      many users move on to more damaging/“harder” drugs;

Question: 6.  Some drug molecules contain a structure that can be represented as follows.

(a) Draw the two enantiomeric forms of this structure.
(b) Explain the term racemic mixture.

Answer: 6.  (a) W
            Z — C — X
            Y
            W

      Must be clearly mirror images.
      (b) an equimolar/50:50 mixture of two enantiomers;  1

Question: 7.  Caffeine and nicotine are two stimulants whose structures are shown in Table 21 of the Data Booklet.
   (a) Describe two similarities in their structures, not including the presence of double bonds,
       methyl groups and nitrogen atoms.  2
   (b) Discuss the problems associated with nicotine consumption, distinguishing between short-term and long-term effects.  6
Answer: 7. (a) both contain six-membered ring; five-membered ring; (tertiary) amine group; N- has methyl group attached; 2 max
(b) short-term effects
increased heart rate/blood pressure/restriction of blood vessels;
acts as an anti-diuretic/reduction in urine output;
long-term effects
increased risk of heart disease/coronary thrombosis;
risk of becoming addicted/physically dependent;
high cost;
(increased risk of) (lung, mouth, throat) cancer;
(increased risk of) bronchitis/emphysema;
reduction in capacity of blood to carry oxygen;
withdrawal symptoms/weight gain (on quitting); 6 max

Question: 8. The effect of some drugs used to treat cancer depends on geometrical isomerism. One successful anti-cancer drug is cisplatin, whose formula is PtCl₂(NH₃)₂. Describe the structure of cisplatin by referring to the following:
- the meaning of the term geometrical isomerism as applied to cisplatin
- diagrams to show the structure of cisplatin and its geometrical isomer
- the types of bonding in cisplatin.

Answer: 8. geometrical isomerism
existence of compounds with the same molecular formula but with atoms/groups or Cl/NH₃ arranged differently in space;
cis trans
Cl Cl
Cl — Pt — NH₃ H₃N — Pt — NH₃
NH₃ Cl
both structures correctly labelled as cis and trans;
covalent bonding/shared pairs of electrons; dative/coordinate/hydrogen/polar bonding; 4

Question: 9. Many drugs and other biologically important molecules consist of chiral species whose activity depends upon the enantiomer used. Adrenaline (a hormone that is also used as a drug) is a chiral molecule.
(a) Identify by means of an asterisk (*) the chiral centre in adrenaline, the structure of which is given below.

(b) Some enantiomers can be prepared by using a chiral auxiliary. Outline how a chiral auxiliary functions and state the advantage it provides. 5
Question: 10. Magnesium hydroxide and aluminium hydroxide can act as antacids.
(a) Write an equation for the reaction of hydrochloric acid with one of the above antacids.
(b) Identify which antacid neutralizes the greater amount of hydrochloric acid if 0.1 mol of each antacid is used to neutralize the hydrochloric acid present in the stomach.
(c) Give one reason why sodium hydroxide is not used instead of these antacids.

Answer: 10. (a) $\text{Mg(OH)}_2 + 2\text{HCl} \rightarrow \text{MgCl}_2 + 2\text{H}_2\text{O}/\text{Al(OH)}_3 + 3\text{HCl} \rightarrow \text{AlCl}_3 + 3\text{H}_2\text{O};$
(b) Al(OH)$_3$/aluminium hydroxide;
(c) corrosive to body/tissue/strong base/alkali;

Question: 11. (a) Describe the likely effect of a depressant taken in:
(a moderate dose)
(a high dose)
(b) Ethanol in breath can be detected using a breathalyser containing potassium dichromate(VI) crystals. Describe the colour change that occurs in a positive test and identify the species responsible for the final colour.

Answer: 11. (a) a moderate dose may induce sedation/reduce anxiety or tension/slower mental activity/slow CNS/causes drowsiness;
a high dose may induce sleep/coma/unconsciousness/death;
(b) orange to green; Cr$^{3+}$/chromium(III);

Question: 12. Penicillin G was the first antibiotic used to fight infections. The structure of this antibiotic is as follows:

(a) Determine the molecular formula of penicillin G.
(b) State **two** reasons for modifying the side chain in penicillin G.

(c) Describe the mode of action of penicillin in preventing the growth of bacteria.

(d) Discuss **two** effects of over prescription of penicillin to humans.

**Answer:**

1. **(a)** \( C_{16}H_{18}O_{4}N_{2}S; \)

   (b) prevents deactivation by stomach acid/more resistant to stomach acid;
   prevents deactivation by the enzyme penicillinase (produced by bacteria)
   /increases resistance/tolerance to penicillinase;

   (c) penicillin interferes with the cell wall formation;
   cells can expand/burst/disintegrate/bacteria die;

   (d) makes penicillin less effective;
   destroys useful/beneficial bacteria;
   allows resistant population to build up;

2. **(a)** Describe the differences in the ways that **bacteria and viruses** multiply.

   (b) Outline **two** ways in which **antiviral drugs** work.

   (c) Explain why effective treatment of AIDS with antiviral drugs is difficult.

**Answer:**

1. **(a)** bacteria multiply by cell division/binary fission/mitosis;
   viruses insert DNA/RNA/genetic material into cells;
   *For “bacteria multiply by themselves but viruses require a host cell”/OWTTE award [I].*

   (b) block enzyme activity within host cell/block reverse transcriptase;
   alter host cell's genetic material;
   prevent virus from multiplying/replicating;
   alter virus's binding site on cell wall/prevent virus binding with cell wall;
   prevent virus from entering/leaving cell;

   (c) HIV virus mutates rapidly;
   HIV metabolism linked to that of host cell/HIV uses host cell;
   Drugs harm host cell as well as HIV/difficult to target HIV without damaging host cell;

2. **(a)** Refer to Table 21 in the Data Booklet when answering this question about **analgesics**.

   (b) Describe the different ways in which mild and strong analgesics prevent pain.

   **mild analgesics:**

   **strong analgesics:**

   (b) Some mild analgesics are derivatives of **salicylic acid**. The structure of salicylic acid is

   ![Salicylic Acid Structure](image)

   (i) Salicylic acid can be converted to aspirin. Give the formula of the group that replaces one hydrogen atom in a molecule of salicylic acid in this conversion.
(ii) State the names of two functional groups present in acetaminophen (paracetamol) and one functional group present in ibuprofen.

acetaminophen (paracetamol)

ibuprofen

Answer 14. (a) **mild analgesics**
they prevent/interfere with the production of substances/prostaglandins that cause pain;
they intercept pain at its source;

**strong analgesics**
they bond to receptor sites in the brain;
pain signals within brain/spinal cord blocked;

(b) (i) CH₃CO;
(ii) acetaminophen (paracetamol) amide;
hydroxy(l)/phenol/alcohol;

ibuprofen carboxylic acid;

Question: 15. Caffeine is a **stimulant** with the following structure.

(a) Determine whether both amine groups in caffeine are primary, secondary or tertiary.

(b) Caffeine contains the group \( \text{C} \equiv \text{N} \). State the general name for this functional group.

(c) Tablets of the drug Ecstasy are sometimes contaminated with a substance called 4–MTA.

Ecstasy

4–MTA
(i) Ecstasy and 4-MTA are sympathomimetic drugs. Identify the structural similarity between the two drugs and epinephrine (adrenaline), the structure of which is given in Table 20 of the Data Booklet. 2

(ii) Outline what is meant by the term sympathomimetic drug and state two examples of short-term effects sympathomimetic drugs have on the human body. 3

(iii) State one example of a long-term effect of taking stimulants. 1

**Answer:**

15. (a) tertiary; 1
   (b) amide; 1
   (c) (i) all contain the phenylethylamine structure/contain an arene or benzene ring linked to two carbon atoms attached to an amine group; 1
   (ii) sympathomimetic drugs mimic the effect of adrenaline; Any two of the following:
   - stimulate the sympathetic nervous system;
   - speed up the heart rate;
   - increase sweat production;
   - increase rate of breathing; 3 max
   (iii) weight loss/constipation/emotional instability; 1

**Question:** 16. Ibuprofen is an analgesic with the following structure:

![Ibuprofen structure](image)

(a) Identify the chiral carbon atom in the structure of ibuprofen using an asterisk (*). 1

(b) Describe how chiral auxiliaries can be used to synthesize only the desired enantiomeric form of a drug from a non-chiral starting compound. Explain why it is important to use only the desired enantiomeric form of a drug and state an example of what can happen if a racemic mixture is used. 5

**Answer:**

16. (a)

![Ibuprofen structure with asterisk](image)

(b) a chiral auxiliary is itself an enantiomer; it is bonded to the reacting molecule to create the stereochemical conditions necessary to follow a certain pathway; once the desired enantiomer is formed the auxiliary is removed; different enantiomers may have different biological effects (some of which may be harmful); genetic defects/deformities; 5
Question: 17. (a) One method for detecting ethanol in breath involves blowing through a tube containing crystals of potassium dichromate(VI). The ethanol turns the crystals from orange to green. Explain what happens to both the dichromate(VI) ion and the ethanol in this reaction. 

(b) A modern method for accurately determining the amount of ethanol in breath uses an intoximeter. Describe how an intoximeter works.

Answer: 17. (a) the dichromate(VI) ion is reduced/forms the Cr$^{3+}$ ion; the ethanol is oxidized/forms ethanal/ethanoic acid;

(b) sample of breath passed into infrared spectrometer; ethanol in breath absorbs because of C-H bond; compares breath with air/reference sample with no ethanol;

Question: 18. (a) State the name of the class of drugs with effects similar to that of adrenaline. Outline one effect of these drugs on humans.

(b) (i) Identify the stimulant responsible for addiction to smoking tobacco.  
(ii) Describe two short-term effects of smoking tobacco.  
(iii) Describe two long-term effects of smoking tobacco, other than addiction.

Answer: 18. (a) amphetamines/stimulants; increased heart rate/increased blood pressure/increased breathing rate/dilation of pupils/constriction of arteries/sweating/increased alertness/decreased appetite;

(b) (i) nicotine;  
(ii) increased heart rate; increased blood pressure; reduced urine output; increased concentration/stimulating effect;  
(iii) increased risk of cancer; increased risk of stroke/(coronary) thrombosis/heart disease; ulcers; emphysema/bronchitis/shortage of breath; coughing/bad breath/yellowing of teeth or fingers; effect on pregnancy;

Question: 19. Diazepam and nitrazepam are two depressants that are very similar in their structures. State the name of two different functional groups present in both depressants.

Answer: 19. amide/ketone/carbonyl; (tertiary) amine;
Question: 20. (a) Lysergic acid diethylamide (also known as LSD or “acid”) and mescaline are both mind-altering drugs. State one effect caused by both substances and one effect caused by LSD or mescaline only. (Specify the substance which causes the effect.) 2

(b) Outline the structural similarities and differences between LSD and mescaline. (Structures are given in Table 21 of the Data Booklet.) 2

Answer: 20. (a) cause changes in visual and sound perception/hallucinations;
LSD may cause a permanent effect of “flashbacks”/effects of LSD may be experienced a year or more after the last use of the drug/psychological dependence; 2

OR
mescaline may cause nausea/trembling/liver damage/reduce appetite;

(b) both contain amines/aromatic (benzene) ring;

<table>
<thead>
<tr>
<th>mescaline</th>
<th>LSD</th>
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<tbody>
<tr>
<td>primary amine</td>
<td>secondary and tertiary amine</td>
</tr>
<tr>
<td>ether groups</td>
<td>amide</td>
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<tr>
<td>one ring</td>
<td>alkene(s)</td>
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<tr>
<td>one ring</td>
<td>indole ring</td>
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<tr>
<td>four cyclic rings</td>
<td>heterocyclic</td>
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Accept any one clear difference from the above list. 2