6. Nucleic Acids and Protein Synthesis

6.1 Structure of Nucleic Acids and Replication of DNA

Paper 2

Marking Scheme

Q1.

(a)	*do not allow 'base' as AW for 'nucleotide'* *any* ***one*** *from:* *idea that* phosphodiester bond forms, between nucleotides on the same strand / between adjacent nucleotides / during polynucleotide formation / to form a sugar-phosphate backbone ; AW *look for understanding that more than one nucleotide needs to be present on the same strand* *idea that* phosphates, shown are only bound to one (pentose) sugars / each phosphate needs to be bound to two (pentose) sugars ;	1

(b)	base / nucleotide, on left identified as guanine and, base / nucleotide, on right identified as cytosine ; **A** guanine and cytosine *as question has DNA-RNA* **I** cytosine and guanine *unless further qualified* dotted line as hydrogen bond / annotation related to dotted lines as hydrogen bonds / there are three hydrogen bonds between the bases; **A** H-bond *circle is* phosphate ; *pentagon / pentose, on left is* deoxyribose ; *also AVP if 'pentose'* double ring / base on left, identified as purine ; **A** guanine is a purine if mp1 gained single ring / base on right, identified as pyrimidine ; **A** cytosine is a pyrimidine if mp1 gained AVP ; e.g. label to any solid line bond as covalent bond phospho-ester bond, labelled / described pentose sugar, label to / described for, deoxyribose / ribose box drawn around one completed nucleotide and labelled 5' and 3' shown annotated ref. to antiparallel nature of base-pair	4

Q2.

(a)	**1** four DNA bases named correctly ; *correct spellings* **2** purine or pyrimidine column correct for **A**, **C**, **G**, **T** ; **3** final column correct ; **4** uracil (*spelled correctly*) and pyrimidine ; *if 0 or 1 mark gained, can increase to max 2:* • if 0 marks, can check for two correct rows • only mp 1, 2 or 3 correct, check for one correct row • only mp 4 correct, check for a correct **A** / **C** / **G** / **T** row	4

base	name of base	purine or pyrimidine	RNA or DNA or both
A	adenine	purine	both
C	cytosine	pyrimidine	both
G	guanine	purine	both
T	thymine	pyrimidine	DNA
U	uracil	pyrimidine	RNA

(b)(i)	purine because it is a, double ring structure / has two rings ; **A** purine because similar structure to, adenine / guanine	1

(b)(ii)	*mp1 / 2 / 4 idea that carbovir triphosphate is more similar to the (activated) DNA nucleotides that are added to the elongating chain by DNA polymerase* *mp3 justifying why it is better to have a nucleotide analogue (carbovir triphosphate) by explaining the role of DNA nucleotides* *look for ora for abacavir* *any **two** from:* **1** carbovir triphosphate is (similar to / same as), an activated nucleotide / a nucleotide / not a nucleoside ; **A** similar to, A / G, nucleotides **I** *ref. to* purine **2** carbovir triphosphate, has (three) phosphates / is activated / is phosphorylated ; **3** detail of, (DNA) polymerase action / (activated DNA) nucleotides ; e.g. (nucleotides are) added to the, growing / elongating, chain (nucleotides) form H bonds with, complementary base / AW (nucleotides are) substrates for DNA polymerase phosphodiester bonds form between nucleotides *allow mp3 in context of carbovir triphosphate (link to mp1)* **4** *ref. to* triangle / triangular cycloalkane, no longer present / not on DNA nucleotides ; **5** AVP ; e.g. carbovir triphosphate better fit to active site of enzyme / AW	**2**

(b)(iii)	*any **four** from:* *carbovir triphosphate can be inserted into a growing chain…* **1** prevents polymerase from adding DNA nucleotide to growing chain / AW ; **A** *idea of* complete (viral) DNA not made if, chain does not elongate / no more nucleotides added **R** adding base **R** *if in context of stop codon / transcription* **I** *ref. to* complementary base pairing **2** similar <u>shape</u> to, substrate / (activated / phosphorylated) nucleotide ; **A** complementary shape to active site of, DNA polymerase / enzyme **3** acts as an inhibitor ; **4,5** further detail of how, inhibitor / carbovir triphosphate, may act ;; *two from = 2 marks* e.g. may be irreversible fits into / binds to, active site of, enzyme / DNA polymerase competes with (DNA) nucleotide for active site **R** base fewer ES complexes form *in context of enzyme with DNA nucleotide* *idea of* fewer enzyme molecules available to bind to nucleotides may cause change in, shape / tertiary structure / 3D structure, of (DNA) polymerase / enzyme **I** *ref. to* complementary base pairing **6** (DNA polymerase) may not form phosphodiester bonds ; **R** between, bases / complementary bases / complementary nucleotides **7** *ref. to* proofreading mechanism ; e.g. error may cause breakdown of (newly synthesised) DNA may be too similar to be noticed as error and not repaired **8** AVP ; e.g. (viral) DNA containing analogue may not be further replicated DNA polymerase cannot move along DNA template strand AW DNA polymerase may become detached from template strand *idea that* carbovir triphosphate, introduces a mutation / changes DNA formed / changes nucleotide sequence	**4**

Q3.

(b)(i)	*must attempt both DNA polymerase and DNA ligase to gain max* *any **five** from:* *DNA polymerase* **1** addition of, activated / phosphorylated, nucleotides ; **2** *ref. to* complementary, nucleotides / bases / strands ; **3** forms phosphodiester bonds ; **4** (between adjacent nucleotides and) elongating / growing, polynucleotide / strand / AW ; **5** *ref. to* proofreading ability of DNA polymerase ; *DNA ligase* **6** joins / AW, Okazaki fragments ; **7** on lagging strand ; **8** forms phosphodiester bonds, between the fragments / to complete phosphate-sugar backbone ;	**5**

Q4.

(a)(i)	S phase / synthesis phase / interphase ;	**1**
(a)(ii)	*any **two** from:* does not have an OH group (on C3) so condensation reaction cannot occur ; phosphodiester bond cannot form between deoxyribose and phosphate of adjacent nucleotide ; is a different shape because it has H instead OH (on C3) ; shape not complementary to the active site of DNA polymerase **or** no, enzyme substrate complexes / ESCs, can form ;	**2**

Q5.

(a)	***one** mark each correct row* **feature** / **mRNA** / **DNA** names of four bases / adenine, cytosine, guanine, uracil / adenine, cytosine, guanine, thymine ; name of pentose sugar present / ribose / deoxyribose ; number of strands / 1 ; **I** single / 2 ; **I** double	**3**

Q6.

(c)	replication / synthesis / AW, of (viral) DNA ; **I** replication of genes **A** *stated function of DNA polymerase* **I** unwinding of DNA e.g. forms phosphodiester bonds joins / AW, (adjacent DNA) nucleotides **R** joins complementary nucleotides **I** joins sugar phosphate backbone	1

Q7.

(b)(i)	guanine ; *any **two** from:* double ring (base) / purine (base) ; forms three hydrogen bonds with complementary base ; AVP ; e.g. detail of difference between adenine and guanine	3

Q8.

(b)	**R** *any answers where a choice is given* **A** hydrogen ; **B** (DNA) ligase ; **C** DNA polymerase ; **R** RNA polymerase **I** roman numerals, e.g. DNA polymerase I **D** telomeres ;	4

Q9.

(a)	*ignore single letters for the bases* **A** *purines* = adenine and guanine ; *in either order* *pyrimidines* = cytosine and uracil ; *in either order* **B** phosphodiester (bond) ; **C** ribose ;	4

Q10.

(a)(ii)	deoxyribose and phosphate and base ; *further detail* *one from* diagram / description, of phosphate group and base attached to deoxyribose ; one correctly named base or A,T C and G ;	**2**

Q11.

(b)(ii)	nucleotide components are base, pentose sugar, phosphate ; UDP has, uracil and ribose and two phosphates / one extra phosphate ;	**2**

Q12.

(a)	adenine and guanine ;	**1**

Q13.

(a)	*three from* joins a nucleotide to extending, polynucleotide / strand ; (only allows) complementary base pairing ; forms phosphodiester bonds (between nucleotides) / forms the sugar phosphate backbone ; proofreading the new strand ; repairs any mismatched base pairs ;	**3**

Q14.

(c)	*max 2 from mp 1 and 2 if transcription described or mix and match transcription and replication* *any five from:* **1** DNA (double helix / molecule) unwinds ; **I** unzips **R** DNA, strand / α helix, unwinds **2** hydrogen bonds break between, base pairs / bases / strands ; **A** hydrogen bonds break between nucleotides *only if clear that two strands are separated* **3** both strands used as templates ; *concise statement* **4** DNA polymerase, qualified ; e.g. involved in polynucleotide formation / phosphodiester bond formation / catalyses synthesis **R** joins phosphates **5** *ref. to* (free) activated (DNA) nucleotides / AW ; **A** phosphorylated nucleotides **R** RNA nucleotides **6** complementary (DNA) nucleotides added ; **R** RNA nucleotides **A** described in terms of complementary base pairing **A** A pairs with T and C pairs with G **7** *idea that* process, occurs / continues, along whole DNA molecule ; **8** *ref. to* Okazaki fragments / movement of polymerase in one direction / nucleotides added in one direction ; **A** correct ref. to leading and lagging strands **9** each newly formed molecule contains one original and one newly synthesised strand ; **10** AVP ; e.g. replication bubbles form / described *ref. to* repair / proofreading *ref. to* helicase (unwinding) / ligase (joining Okazaki fragments) *in correct context* **R** ligase joining phosphates process occurs, step-by-step / sequentially / AW *ref. to* RNA primers	**5**

Q15.

(a)(i)	30% ; **A** anywhere in the answer bases, are paired / are complementary ; **A** with *ref. to* binding **A** hydrogen bonds between, A and T / C and G **A** thymine *or* T pairs with adenine *or* A / cytosine or C pairs with guanine or G calculation / explanation for 30% ; e.g. A+T = 40%, C+G = 60%, half of 60% = 30%	**3**

Q16.

(a)(i)	A = adenine T = thymine **R** thiamine / thyamine G = guanine C = cytosine *all correct = 2 marks* *one, two or three correct = 1 mark*	**2**

(a)(ii)	*three from:* 1 complementary base pairing / complementary bases / base pairing / base pairs / complementary pairing ; 2 A with T <u>and</u> G with C ; 3 hydrogen bonding / hydrogen bonds ; *in context of between base pairs / holding strands together* 4 ref. to purines with pyrimidines ; 5 double ring (bases) with single ring (bases) ; **A** *idea of* longer base with shorter base 6 two (DNA), strands / polynucleotides ; **A** two chains **A** double helix (as double implies two strands) **7** strands (anti)parallel / distance between strands always the same ;	**3**
(b)	deoxyribose ; **A** 2-deoxyribose / 2-deoxy-D-ribose	**1**

Q17.

(c)(i)	using / AW, water / H_2O ; to break bond (between phosphate groups) ; **R** if bond incorrectly named	**2**

Q18.

(c)

feature	DNA nucleotide	RNA nucleotide
sugar component	deoxyribose	ribose ;
purine bases	adenine / A guanine / G	adenine / A guanine / G } ;
pyrimidine bases	cytosine / C thymine / T	cytosine / C uracil / U } ;

R *thiamine for thymine*

3

Q19.

(c)

feature	DNA nucleotide with adenine	RNA nucleotide with adenine	ATP
contains nitrogen (yes or no)	yes	yes	yes ;
contains a pyrimidine base (yes or no)	no	no	no ;
number of phosphate groups	1	1	3 ;
name of the sugar component	deoxyribose ;	ribose	ribose ;

5