2 Read the passage below and answer the questions which follow.

DNA vaccines

Mice and monkeys have been successfully immunised against several important infectious diseases using experimental DNA vaccines, in the form of plasmids. Plasmids are small circular DNA molecules.

During the 1990s, researchers found that mouse muscle and other mouse tissues were able to absorb plasmids which had been injected into the animals. Any genes that were part of this plasmid DNA were transcribed and translated. The resulting proteins were transferred to the plasma membranes (cell surface membranes) of the mouse muscle cells. The proteins were exposed on the muscle plasma membranes together with receptor molecules that allow the immune system to recognise cells as self or non-self. Proteins that are presented at the cell surface in this way stimulate the lymphocytes of the immune system very effectively.

This discovery allows plasmid DNA to be used as a vaccine, even though the DNA does not itself act as an antigen. Most vaccines contain proteins, or fragments of proteins, that are extracted from the surface of pathogens. It is a complex and costly procedure to purify these protein antigens.

Fig. 2.1 shows a simplified diagram of a DNA vaccine. This plasmid codes for two antigens, **A** and **B**.

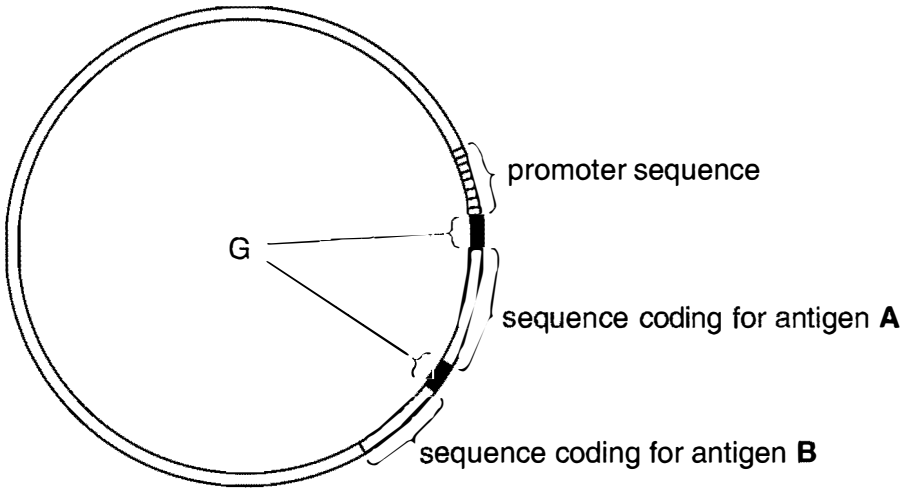

Fig. 2.1

(a) State **three** ways in which the structure of plasmid DNA differs from the structure of a protein molecule.

	plasmid DNA	*protein*
1.	nucleotides / sugar + phosphate + base ;	amino acids ;
2.	4 different subunits ; phosphodiester bonds ; **A** phosphoester	20 different subunits ; peptide bonds / polypeptide ;
3.	contains P ; double-stranded / double helix ; circular ;	contains S / disulphide bonds ; may have 4° structure ; ref to, 2° / 3°, structure / AW ;

AVP ; e.g. role of H bonds

(b) (i) Define the term *antigen*, as used in the passage.

(i) stimulates, immune response / production of antibodies / T or B cells ;

..... [1]

(ii) Suggest why proteins presented at the cell surface are able to stimulate an immune response more effectively than proteins dissolved or suspended in the blood or tissue fluids.

stimulate, cell-mediated immunity / T cells ;
antigen, remains in body longer / continuously produced ;
antigens in blood only stimulate, humoral immune system / B cells ;
antigens (in blood) lost in urine / broken down in liver ;
ref to MHC ;

..... [1]

(c) (i) Explain why a promoter sequence is needed as part of the plasmid if the vaccine is to work.

binds RNA polymerase ;
allows, transcription / production of mRNA ;
switches gene on / allows gene expression ;

.....

..... [2]

(ii) Suggest why it may be desirable to include nucleotide sequences coding for more than one antigen in a DNA vaccine.

(ii) (protect against) more than one, strain / disease / pathogen / AW ;
stronger immune response ;
less likely mutant form will escape immune response / AW ;
AVP ; cheaper / reduces number of vaccinations

.....

..... [2]

(iii) Sequences of nucleotides, labelled **G** on Fig 2.1, code for groups of amino acids at the beginning of each polypeptide. These amino acid sequences direct the newly synthesised polypeptides to the Golgi apparatus of the muscle cell.

Explain how this makes the vaccine effective.

iii) Golgi modifies protein / polypeptide / AW ;
forms glycoproteins / add sugars *or* carbohydrate ;
Golgi forms vesicles ;
..... incorporated into cell membrane ; **R** exocytosis .....
AVP ;
..... [2]

.....

For Examiner's Use

(d) Suggest **three** reasons why researchers may be more concerned about the potential risks of DNA vaccines as compared with protein-based vaccines.

1 . *cells that take up DNA vaccine might* .....

.... **1** function less well ; .....
2 be killed by immune system / trigger auto-immune response ;

2 . **3** have genes disrupted / mutation ; .....

.... **4** new gene might be inherited / AW ; .....
5 plasmid could enter bacteria ;

3 . **6** superbug / create new disease / AW ; .....
7 effects unknown / new technology / no human trials ;

.... **8** AVP ; ref ethics, ref irreversible ..... [3]

[Total: 14]