Syllabus	
Topic	Cardioplegia

David is a 69 year old man listed for coronary bypass grafting (CABG). He has triple vessel disease not amenable to stenting.

a)
The surgeons are using cardioplegia solution. List two purposes of cardioplegia solution. (2 marks)

1. ....

2. ....

b)
Name the main component of cardioplegic solutions and state its concentration (mmol/L). (2 marks)

Main component: ……………………………………………………………………………………………..

Concentration: …………………………………… mmol/L

c)
State the mechanism of action by which the main component of cardioplegia invokes cardiac arrest. (2 marks)

....

....

d)

Below is a table of other common additives to cardioplegia solution with their physiological actions. Complete the two missing substances and physiological actions in the blue shaded boxes. (4 marks)

Typical composition	Physiological actions
Calcium at a lower concentration than plasma	………………………………………………………………………………………… ………………………………………………………………………………………… …………………………………………………………………………………………
…………………………………………………	Prevents loss from the cells, thus maintaining its role as enzymatic cofactor, and competes with calcium, thus reducing Ca^{2+}-induced contraction
Mannitol	………………………………………………………………………………………… ………………………………………………………………………………………… …………………………………………………………………………………………
…………………………………………………	To offset tendency to metabolic acidosis associated with ischaemia
Other additives: Procaine	………………………………………………………………………………………… ………………………………………………………………………………………… …………………………………………………………………………………………

e)
By which two routes can solutions of cardioplegia be administered? For each route, state where the cannula is applied. (4 marks)

Route 1: ....

Cannula placement: ....

Route 2: ....

Cannula placement: ....

f)
Cardioplegia may be blood or crystalloid. State 3 physiological advantages of blood cardioplegia over crystalloid cardioplegia. (3 marks)

1. ....
2. ....
3. ....

g)
List 3 possible complications of cardioplegia solution administration. (3 marks)

1. ....
2. ....
3. ....

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Q	Answer	Mark	Guidance
a)	• Myocardial protection/preserve myocardial function/prevent cell death • Facilitation of surgery – still, relaxed heart	1 1	Allows manipulation of extracellular environment to minimise ongoing metabolic activity and its deleterious effects during period of sub-optimal perfusion
b)	• Main component: potassium • Dose: 20mmol/L (approximately)	1 1	
c)	• Potassium inactivates fast inward sodium channels • Prevents upstroke of the myocyte action potential	1 1	This renders the myocardium unexcitable and in diastolic arrest
d)	<u>Calcium</u> **Physiological action:** maintains cell membrane integrity (but keep the concentration low to reduce amount available for myocardial contraction, thus avoiding myocardial activity) **<u>Magnesium</u>** <u>Mannitol</u> **Physiological action:** to raise the osmolarity of the solution, thus reducing tissue oedema **<u>Bicarbonate/histadine</u>** <u>Procaine</u> **Physiological action:** decreases excitability/conduction/reduction of arrhythmia at reperfusion	1 ½ 1 ½ 1	Other typical additives are sodium + chloride (usually at levels near those found in plasma). Other possible additives are: aspartate, glutamate, adenosine, L-arginine, N-AC, nicorandil, bupivacaine. Glutamate and aspartate are sometimes added to cardioplegia to promote oxidative metabolism in energy-depleted hearts. (Although the optimal composition of cardioplegia solution is subject to debate and ongoing research, it should be slightly hyperosmolar (to limit oedema i.e. mannitol), alkalotic (to address pH changes i.e. buffer) and have a low calcium concentration.)

e)	Route 1: • Anterograde approach • Cannula into aortic root/coronary ostium Route 2: • Retrograde approach • Cannula into coronary sinus	 1 1 1 1	Via this approach, a competent aortic valve is required in order for the cardioplegia to perfuse the coronary arteries and prevent detrimental LV dilation. This route may reach parts of the myocardium inadequately perfused by the coronary arteries, but may be insufficient for the RV as a sole technique. N.B. Cardioplegia can be administered to both routes. It is usually delivered intermittently, every 15-30 mins.
f)	• Oxygen carrying capacity • H+ ion buffering • Oxygen free radical scavenging • Delivery of other nutrients • Reduced myocardial oedema • Improved microvascular flow	Any 3	Blood is superior at preserving myocyte and endothelial function resulting in reduced incidence of mortality, myocardial infarction, and left ventricular failure in high-risk patients. Note that the haemoglobin content of blood used for cardioplegia is diluted to around 5 g dl^{-1} and its p50 on the oxygen haemoglobin dissociation curve is displaced to the left. This will decrease potential oxygen delivery to the myocardium significantly

g)	• Direct damage associated with the cannulae • Failure to attain widespread cardiac perfusion with cardioplegia, leaving areas of myocardium warm and active whilst ischaemic • Fluid overload • Myocardial oedema, haemorrhage and injury resulting from high infusing pressures • Air bubbles in cardioplegia solution can cause air emboli in the coronary arteries	Any 3	Remember to include issues that may arise from the method of administration as well as from the cardioplegia itself. Bubble trap used

References:

1) Scott T, Swanevelder J. Perioperative myocardial protection. CEACCP (2009) 9(3)97-101 https://academic.oup.com/bjaed/article/9/3/97/388530

2) Machin D, Allsager D. Principles of cardiopulmonary bypass. CEACCP (2006) 6(5)176–181 https://academic.oup.com/bjaed/article/6/5/176/337119